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A

SYSTEM OF SURGERY.

VOL. II.

LOCAL INJURIES.

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A

SYSTEM OF SURGERY

THEORETICAL AND PRACTICAL

IN

TREATISES BY VARIOUS AUTHORS.

EDITED BY

T. HOLMES, M.A. CANTAB.

SURGEON AND LECTURER ON SURGERY AT ST. GEORGE'S HOSPITAL:
MEMB. CORRESP. DE LA SOCIÉTÉ DE CHIRURGIE DE PARIS.

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CONSERVATOR OF THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.

Re-edited by J. W. Hulke, Esq., F R.S.

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BURNS AND SCALDS.

◆

BURNS and scalds are, beyond all comparison, the most commonly fatal injuries which occur in civil life;* and the liability to this accident appears to have been largely increased of late years, by the extended use of steam machinery, the invention and universal employment of lucifer-matches, and the nature of the modern materials and fashion of female dress. They are also, of all accidents, those which involve the most agonising pain and the most protracted suffering; and they frequently condemn the unhappy patient to a lifelong mutilation of the most repulsive and distressing kind: they are surrounded in every period of their course by dangers, against which constant precaution must be taken: they require sedulous attention to procure the healing of vast ulcerated surfaces, to prevent deformity, to support the patient's strength, to obviate or cure visceral mischief: and they often offer most gratifying rewards to skill and patience, even in cases where ulceration has been pronounced incurable, or deformity condemned as irremediable. For all these reasons they deserve a more attentive consideration than they usually receive from either students or practitioners of surgery.

These injuries have been variously classified into four divisions by Heister and Callisen,† into six by Dupuytren,‡ and various other divisions have been proposed; all of them indicating the depth of tissue implicated in the injury. Of these, Dupuytren's is the one which is most widely accepted, and which seems at once the most complete and the most practical. I shall therefore follow it in this essay, merely observing that, although of great utility, it does not, and is not intended to, embrace all the elements necessary for prognosis and treatment. It indicates the *depth* of the burn at its deepest part; but another, and perhaps even more important, consideration is the *extent* of the burnt surface—a matter which necessarily eludes formal classification.

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* Mr. Crompton quotes the following statement from the Registrar-General's report for 1845: 'Whilst 3,305 persons were killed in one year by every kind of mechanical injury, in the same period 3,057 were lost by fire, viz. 148 by explosions, 2,577 by burns, and 332 by scalds.'—*Trans. of the Provincial Med. and Surg. Ass.* vol. xviii. p. 19.

† See Frank, *Lehrbuch der Chirurgie,* 1849, vol. i. p. 340.

‡ *Leçons Orales,* &c., Paris, 1839, vol. iv. p. 508.

The six classes, then, into which the great French surgeon divided burns and scalds are these: *First*, Erythema, or superficial irritation (‘*phlogose*’) of the skin, without formation of phlyctenæ. *Second*, Cutaneous inflammation, with separation of the epidermis, and formation of vesicles filled with serosity. *Third*, Destruction of the papillæ and part of the thickness of the skin. *Fourth*, Disorganisation of the entire skin down to the subcutaneous cellular tissue. *Fifth*, The conversion into eschars of all the superficial parts, and of the muscles down to a distance more or less considerable from the bone. *Sixth*, The carbonisation of the whole thickness of the burnt part. Of course, burns, which according to this classification are described as of a particular degree, will often, and indeed usually, involve all the lower degrees as we proceed further from the spot at which the burn has been most intense.

The first degree is characterised by mere superficial redness, fading without any definite edge into the natural skin, and by a tingling sensation, and often intense tenderness to the touch. The injuries of this kind which surgeons have to treat (for the slighter cases are seldom brought under medical care) are often very extensive: being produced by the sudden and transient application of flame over a great part of the body, as in explosions of gas. They are then very grave accidents from the depressing influence which is exerted upon the brain and heart, although in all such cases the local injury is not formidable, since no sloughing is to be apprehended. The epidermis will remain to protect the surface of the true skin till a fresh layer is produced, when it separates, and the case is at an end.

In the second degree, the local injury has been carried a little farther, and the sudden afflux of blood to the surface of the cutis has been relieved by the transudation of the serum from its vessels, forming bullæ. Here the skin is in more danger than in the former case, since the detached epidermis is very liable to be peeled off, especially in extensive scalds, where the detachment is often very considerable, and where it is not rare to see a glove of epidermis separate from the hand or foot of a patient, just as it does from a macerated subject.

In the third and fourth degrees of burn, the true skin is involved, partially in the former, and in its whole thickness in the latter. It is a matter of importance to distinguish these two varieties from each other, in reference to the question of the probability of resulting deformity; but it must be confessed that it is not always possible at first. The surface in both is burnt dead, and is hard, tough, parchment-like, mottled with the débris of the blood which was contained in the tissues, and varying in colour in different cases: this variation depending either upon differences in the agent by which the accident has been produced, or upon other causes difficult of determination. Beneath this eschar lies, in the former case, the deeper part of the cutis, not disorganised, but in the commencing stage of the inflammation which is a necessary consequence in the separation of the slough; in the latter, merely the loose subcutaneous cellular tissue, which is itself in most cases somewhat frizzled by the heat. The cellular tissue therefore generally contracts to some extent, so that the skin around the eschar is more puckered in the severer than in the less serious injury; and the eschar also in the former has a denser and more parchment-like appearance than in the latter. It is difficult to give an idea of this by description; but those who are familiar with these injuries soon acquire a tolerable idea of the depth of the eschar from its outward aspect. To these signs of difference Dupuytren adds, that the pain on pressing the burnt part is much greater when the burn does not involve the whole skin, and therefore the sensitive cutis receives the transmitted impression, than where the whole skin is destroyed, and the pressure is received by the less sensitive cellular tissue. This symptom, however, varies so much in different persons, and is so wholly delusive in children, who are the most frequent subjects of burns,* that it cannot often

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* The extract from the Registrar-General's report, above given (p. 1), proceeds as follows: 'Upon analysing the 2,909 deaths by burns and scalds, there were of Males between the ages of five and ten . . 275

„ under the age of five	799
Total . . .	1074
Females between the ages of five and ten . .	528
„ under the age of five	672
Total . . .	1200

Total males and females under ten years 2,274; leaving the small proportion of 635 for both sexes above the age of ten.' (Loc. cit.)

establish the diagnosis. If the true skin is involved to any extent, it is best to give a guarded answer when consulted as to the probability of deformity resulting, at least until the separation of the slough enables us to judge of the depth of the mischief. When the whole skin is destroyed, it is only by the greatest care that contraction can be prevented; and when the destruction involves any large portion of it, some amount of contraction is inevitable.

The deeper burns are far less common, and the total carbonisation of a member, which constitutes Dupuytren's sixth degree, is fortunately hardly ever met with, except occasionally in the fingers and toes, since in thicker parts it requires exposure to the flame for a period which almost involves the necessity of the patient having been utterly insensible, or forcibly hindered from moving his limb, as in the case quoted by Dupuytren from Roche, where a young man had his leg jammed into a vessel of molten metal, from which he could not extricate it. In these deep burns the surface is utterly insensible, charred, and brittle. The skin is sometimes shrivelled up, allowing the dried fasciæ or tendons to be seen through it; and the parts so charred may be broken away without pain to the patient. In the burns of the highest degree, any part or the whole member may be removed within the area of the burn without the patient being conscious of it.

Etiology.—The causes of burns and scalds exercise some influence on the progress of the case, and consequently should always be taken into account in the prognosis. The most common, and unfortunately also one of the most fatal, accidents of this nature, is the prolonged application of flame to a large part of the body by the clothes catching fire. The cause furnishes a considerable proportion of deaths to the yearly returns of all our hospitals, and is very fatal in children. The sudden explosion of gases is another common injury; and, however superficial such burns may be, they should never be looked upon lightly, as the extensive interference with the functions of the skin which is thus caused is liable, as we shall presently see, to be followed by grave consequences, even in cases which do not prove immediately fatal from the shock and pain of the accident. The contact of molten and red-hot metals, and of substances at a high temperature, which also act chemically on the tissues, is a cause of very deep burns, which are sure to be followed by sloughing. In explosions, the mechanical violence done to the part has also to be taken into account; and in those of gunpowder we must remember that the unconsumed grains of the powder are projected into and stick in the skin, conjunctiva, &c., and should be removed when practicable.

The heat of the sun, 'insolation,' as Dupuytren * terms it, is asserted by him to be occasionally the cause, especially in hot countries, of severe burns, several cases of which have, he says, been put on record, in which severe inflammation ensued, followed by gangrene and death on the fourth or fifth day. No reference is given, and I am not aware on what authority these facts rest. The only instance which I ever saw of a person being so severely scorched by the sun's rays as to require medical attendance, was during the almost tropical heat of the summer of 1859 in London, when a young lad who had been exposed to the sun naked for some time while bathing, was admitted into St. George's Hospital, with the whole of the skin of the back burned in the first degree, and large bullæ raised upon the scapulæ. He, however, recovered speedily. †

Scalds are usually less severe accidents than burns, as the heated fluid generally remains only a short time in contact with the part; so that many of them escape sloughing. Their extent, however, often compensates, as it were, for their superficiality; and special circumstances render certain scalds even more deadly than the other varieties of these frightful injuries. I allude especially to those scalds of the larynx which are not uncommon in infants from swallowing boiling water, or inhaling steam from the spout of a kettle (see INJURIES OF THE NECK).

Very deep and formidable injuries are often produced in manufactories by persons falling into, or being scalded by, liquids denser than water, and which retain their fluidity at a point higher than that at which water boils. These dense fluids seem to adhere to the skin, and run down it, causing a sort of serpiginous sloughing ulcer, very difficult to heal on exposed surfaces, and which is liable to follow the flexures of the limbs, when it is apt to be succeeded by adhesions limiting their motion.

Another point of importance in reference to the causes of burns is, that various bodily conditions, principally connected

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* Loc. cit. p. 506.

† See *British Medical Journal*, 1859, p. 579.

with morbid states of the brain, often occasion the accident. Thus epilepsy, apoplexy, fainting fits, and such-like affections, are very common causes of burns. Drunkenness, also, is a frequent occasion of this, as of every other accident, and is very liable, under the combination of prostration and pain which follows a severe burn, to give rise to delirium tremens. I am not aware that in epileptics the disease is usually, or even often, aggravated by the accident; at least, I have seen several cases in which no such effect was produced; nay, it has even been proposed to treat epilepsy by 'firing;' a proposal little likely to find favour in the present day.

When, from any of the foregoing causes, such as coma, intoxication, or the fumes of charcoal, complete insensibility has been produced, it is possible that the whole body should be consumed gradually if the clothes accidentally catch fire. The sufferers from this accident are always very fat; and it is to this circumstance, and not to any fancied combination of alcohol with their tissues, that Dupuytren is inclined to ascribe the possibility of so singular an event. The skin is dried, charred, and cracked by the heat, the subcutaneous fat is in the mean while melted, and then pours out from the cracks in the skin, feeding the conflagration, and extending it in a similar manner to other parts of the body, till at length all that is left of what was so lately a human body is a few ashes, and perhaps some melted fat. This is what is called 'spontaneous combustion;' an accident rare in any form, and which appears never to occur really spontaneously, but always as the consequence of a burn. The subject is most graphically treated in the *Leçons orales*,* to which I would refer the reader for the arguments and details relating to a fact which is too remote from ordinary experience to possess much practical interest.

Finally, I may add that burns are sometimes produced by the action of lightning; but the burn is not usually a prominent feature in such accidents. The whole subject of accidents from lightning will be considered further on.

Prognosis.—The prognosis in burns and scalds depends in general on the age of the patient, the extent of the injury, and its depth; and the importance of these particulars may be estimated in the order in which I have stated them. Children are peculiarly liable to the numerous secondary visceral complications which will be pointed out as being frequent sequelæ of burns, and are especially ill-calculated to resist them; so that the risk of cerebral or thoracic affections in children is out of all proportion greater, even after comparatively slight injuries, than in grown people: and it need hardly be said that the opposite extreme of life is a condition in which its impending termination is liable to be hastened by any injury, however slight. Hence, in both the prognosis is unfavourable. The extent of surface involved is a very essential feature in the case. Even when the burn is only of the first or second degree, the shock of the application of fire to a large surface, and the intolerable pain which it occasions, renders the prognosis doubtful; and where the substance of the cutis is involved over a large part of the body, and suppuration must take place along the whole extent of the wound, the chance of recovery is very small. The other primary considerations (by which I mean considerations which influence our judgment as to the probability of death or recovery) are the situation of the injury, and the length of time which has elapsed since its infliction. Burns and scalds of the chest are of all others the most fatal, particularly in children; those of the abdomen are often followed by peritonitis, those of the neck by laryngeal inflammation. Burns of the scalp are very liable to erysipelas and diffuse inflammation, but are not, as far as I have observed, so often followed by cerebral mischief as we should have expected.* When limited to the extremities or to the back, where the thick muscles serve as a protection to the subjacent viscera, these injuries are far less fatal. The lapse of time is always a favourable feature in the case, since the mortality from burns exhibits a progressive decline as we advance farther from the accident. But it must not be forgotten that the period of the separation of the slough brings with it peculiar dangers in burns of the fifth degree, from hæmorrhage and the exposure of the great serous or synovial cavities.

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* Loc. cit. p. 513.

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* A remarkable instance of the immunity which the brain often enjoys, even in very severe burns of the head, may be found in Dr. Hayward's *Surgical Reports*, Boston (U. S.), 1855, p. 264. A still more singular example of the same fact is exhibited in a preparation in the Museum of St. Bartholomew's Hospital (Series I. No. 100), the skull of a lunatic, who had put his head into the fire for the purpose of committing suicide. A third part of the skull has exfoliated, but the brain has not suffered in the least; and the man survived twelve years.

Besides, however, the question of life and death, there is the very important consideration of the local result. Will the ulcer which is left be curable? What is the prospect of deformity from cicatrisation? These questions will be more conveniently discussed in considering the treatment of each degree of burn.

Symptoms.—The first and most prominent, and perhaps also the most important symptom in a burn, is *pain.* No other of the many terrible injuries which it is the duty of surgeons to study approaches these in painfulness; and it is a merciful provision of nature which renders the prolongation of life impossible under the torture of a very extensive and deep burn. In cases somewhat milder than these the pain varies very much, both in severity and duration, in different persons and in different degrees of the injury. As a general rule, the deeper kinds of burn are not so painful as those in which a portion of the true skin has been involved, but yet the sensibility of the organ of touch has not been exhausted by the carbonisation of its whole thickness. The pain, however, in almost every case is very severe, and ought, at least in adults, to be promptly met by the exhibition of an adequate dose of opium, before any other measure is taken. It will usually subside rapidly after this (although it seldom disappears), on the application of some of the non-conducting substances in common use as dressings, but occasionally resists all such means, and requires fresh doses of opium, sometimes often repeated. In burns confined to a limited spot no other symptoms are produced besides the pain and local injury, except some temporary quickening of the circulation from excitement; but it is not of these that I wish to speak here, so much as of those which Mr. Crompton * calls 'constitutional burns.' Here the effect on the general system is shown at once by extreme prostration (especially if the pain have been intense and long-continued), pallor, and a peculiar terror, which frequently lasts some time in children. Delirium is often an immediate consequence of the accident. Rigors very frequently occur, and mark a severe form of the injury. The intolerable heat of the burnt part is soon replaced by a distressing chilliness, the consequence probably of suspended or obstructed circulation. The pulse is quick and weak, the tongue and mouth often dry, and thirst great. These latter symptoms are more severe, and great dysphagia may exist, when, as is often the case, the flame has passed into and scorched the mucous membrane of the mouth and pharynx.

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* Loc. cit.

In this stage of collapse the patient often dies without making any effort at rallying. Death is sometimes ushered in by convulsions or delirium; at others the functions of the great nervous centres remain unimpaired, or the congestion of the brain is manifested by drowsiness, and occasionally by vomiting.

This stage of prostration, or of congestion, as it has most appropriately been termed, lasts a variable time (two days being arbitrarily assumed as its limit, a limit which exceeds the reality in ordinary cases), and is followed by a period of reaction, in which, if at all, acute inflammation is to be apprehended. There is now often some degree of general fever, but this is by no means a constant symptom. The bowels are generally constipated at first, and this constipation in many instances soon gives place to diarrhœa. Vomiting often persists and sometimes exhausts the patient. This symptom, combined with diarrhœa and blood in the motions, is usually considered symptomatic of ulceration in the duodenum. Diarrhœa by itself is a very uncertain indication of any precise anatomical lesion; it is, however, a symptom by no means to be neglected, as it seems frequently to exhaust the strength with a rapidity more than proportioned to its apparent violence. When it is not accompanied by mechanical lesion of the gut, or acute enteritis, it is usually under the control of astringents, which should be combined with laudanum and alcoholic stimulants. When thoracic inflammation occurs, it is generally about this period: its symptoms are very frequently obscure; limited, perhaps, to slight cough and dyspnœa, even when the lungs are extensively hepatised. Sometimes, however, when the pleura is affected, especially by the irritation of a burn on the chest, the pain is very severe. The sloughs which form in the deeper burns are now separating, and the discharge from them adds to the weakness which is characteristic of all periods of these injuries, more especially, however, the first and last. Hemorrhage sometimes occurs on the separation of the sloughs when they are in the vicinity of large vessels, or even earlier, from the force of the blood breaking through the charred tissues, and may prove fatal. Thus a man was brought into St. George's Hospital several years ago who had burnt the back of his throat with a red-hot poker in performing some juggling tricks. It was on the second day after the accident that bleeding first occurred from the right internal carotid, and returned on the day following with such violence, that although the common carotid was secured, and no further bleeding took place, he sank rapidly. Arterial hæmorrhage is, however, very rare in burns. I find no other case noted in the Hospital Case-book, which extends over twenty-five years, and contains the history of every patient who has been examined after death. The cause of this rarity is, doubtless, that the large arteries lie under the protection of strong fasciæ, which are very seldom burned through, except in injuries so severe as to destroy life before the time at which hæmorrhage would come on.

The limits which separate the second period, that of reaction and inflammation, from the third, that of exhaustion or suppuration, are even more arbitrary than those which mark the passage from congestion to inflammation. I shall follow other writers in taking the end of the second week as the termination of the second period for statistical purposes; but it must be understood that in each individual case the third stage is reached after the sloughs have separated, and the process of suppuration has become fairly established, from the whole surface of the wound. In this third period, internal inflammations, though not so frequent as in the second, are by no means rare. They are still more decidedly of the asthenic form, and are often entirely latent, being revealed from time to time in the post-mortem examination of patients who appear to have sunk from pure exhaustion. The general symptoms are usually those of weakness merely; sometimes the bowels continue irritable for a considerable time; occasionally, in children, convulsions come on at a late period of the case when none had occurred earlier. The various complications to which these, like other wounds, are subject, may come on at any period. Tetanus, erysipelas, and diffuse inflammation are not, as far as I have observed, more frequent complications of these than of other accidents: while pyæmia is decidedly rare. As the case progresses, the local phenomena gain in relative importance upon the constitutional, until at length an old burn terminates as a case merely of vicious cicatrisation or obstinate ulcer. In this stage it may last an indefinite time, or remain absolutely incurable.

Burns are liable to prove suddenly fatal at all periods of their course; though this accident becomes more rare as the injury becomes more remote. The most common cause of sudden death at the commencement of the case is convulsions in children, in whom this complication is usually, if not solely observed. After the fourth or fifth day, death may be produced suddenly by an ulcer of the duodenum perforating an artery* or the peritoneum. Some rare cases prove fatal at various periods from causes which baffle pathological inquiry. In some of those cases ulcers of the duodenum have been found, and vomiting has preceded death; but this hardly accounts for the rapidly fatal and unexpected seizure.

Pathology and Treatment.—The treatment of burns divides itself naturally into two very different parts, the local, and the constitutional. The former is best determined by experience, and by attention to the general rules of surgery; for the latter a knowledge of the remote consequences of these injuries is required, which can only be obtained by post-mortem investigation.

I shall, therefore, endeavour to set before the reader, more fully than has been done elsewhere, as far as I can discover, the pathology of these injuries, with a view to determine the viscera or functions which are more peculiarly threatened, the causes and modes of death, and hence the indications for their constitutional treatment.

The pathology of burns has been more closely studied, and the importance of the remote lesions which they produce in the viscera has been more accurately appreciated, since Dupuytren† called the attention of the profession to the prevalence of inflammation of the gastro-intestinal mucous membrane, and Mr. Long‡ gave precision to this observation by pointing out the ulceration of the duodenum which so frequently accompanies severe burns. The only pathological researches, however, with which I am acquainted, which are at once accurate and extensive, are those of Mr. Erichsen,§ who has tabulated fifty fatal cases of burns and scalds in order to determine the organs most frequently affected in each degree and period. I shall make frequent reference to this valuable table, and to another similar table in my own possession, compiled from the case-books of St. George's Hospital, and containing a full account of the history and post-mortem appearances in seventy-five fatal cases.

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* See the illustration on p. 22.

† Op. cit. pp. 521–525.

‡ *London Medical Gazette*, Feb. 1840.

§ *London Medical Gazette*, Nos. 789, 790.

As the method and principal cause of death is a point of the greatest importance to ascertain, in order to determine the general direction which our treatment should take, I have examined the notes of those seventy-five cases with a view, if possible, of deciding this point. Mr. Erichsen's table does not contain the symptoms during life, and is therefore not available for this purpose.

Seven cases must be deducted, in which the history does not enable us to draw any positive conclusion, or where the patient died of some other disease. Of the remaining sixty-eight, nine died of shock, all within two days; seventeen of exhaustion, accompanied in some cases by visceral lesion, but without any striking functional disturbance. Five of these cases proved fatal within a week, but the majority survived for a much longer period. Erysipelas was seldom noticed, and proved fatal in only three instances, in all of which the scalp had been burnt. Pyæmia is a rare accident in burns, as might have been anticipated from the fact that the bones are rarely injured, and that phlebitis is almost unknown. It occasioned death in three cases, one of which, however, was somewhat doubtful. Two died of tetanus. Thus thirty-four, or exactly half the cases, died of affections of a low type not depending on local mischief or visceral disease.

Passing on now to the affections of individual organs, we find that the brain was the seat of fatal mischief in eleven cases. All of these were children, and nine of them under five years of age. The death usually took place soon after the accident, but in three cases the fatal seizure did not occur till a late period. The brain was in most cases found congested and wet; in two inflammatory softening existed.

Six cases died from inflammation of the larynx or trachea; five of the patients were children; one a woman seventy-eight years old. They all died within two days, except one, who survived till the third. Tracheotomy was tried in two cases, and in one was thought to have prolonged life.

Twelve died from thoracic complications. In all of these the chest, or its immediate neighbourhood, was injured; all, except four, were children. The periods at which the cases proved fatal were very various.

Four only died from the direct effects of abdominal lesions, and in one of them the manner of death was obscure. One was a case of peritonitis, occasioned by a deep burn on the abdomen. Two others died from sudden hæmorrhage in ulcers of the duodenum. The period of death was ten and five days respectively. The fourth case was one of those obscure instances of sudden death which sometimes occur in these injuries. The patient had gone on satisfactorily for more than ten weeks, and was then seized with vomiting, which proved fatal on the same day. Nothing was found to account satisfactorily for the rapidity of the death; but, as the duodenum was found extensively ulcerated, it is classed in this category. It is most probable that the vomiting was connected with this ulceration, and death might have been induced by some affection of the great sympathetic ganglia in the neighbourhood. This is a point, however, on which it is not worth while to theorise here. We are only concerned to remember that these sudden and obscure deaths are not very uncommon in burns, and have been noticed by many authors. Hence it is always prudent to be a little reserved in our prognosis.

One case remains to be accounted for; in this the patient died of hæmorrhage from the internal carotid artery.

Possibly this may be more easily followed in a tabular form. Of 68 fatal cases of burn, examined after death,

34 seemed to die from general causes, viz.:—	9 of shock. 17 of exhaustion. 3 of erysipelas. 3 of pyæmia. 2 of tetanus.
34 from the effect of local lesions, viz.:—	11 of cerebral complications. 6 of laryngitis. 12 of thoracic complications. 4 of abdominal lesions. 1 of hæmorrhage from the carotid artery.

The above facts show how much more common, especially in adults, is death from shock and from exhaustion than from any internal inflammation, and how nugatory antiphlogistic measures and severe regimen must be, which are directed against apprehended inflammation; measures which are at all times of doubtful utility in checking such inflammation, while they cannot fail to aggravate the tendency to exhaustion, which is so much more to be apprehended, and so much more likely to prove mortal. The actively-fatal inflammations of the peritoneum, pleura, and lung are hardly ever met with, except in lesions of the parietes which enclose them. Adults hardly ever die of any other cerebral affection after burns than delirium tremens.

Pathology of the first period.—Of the cases of burn that prove fatal, a great majority die in the *first period* of the disease, that is, in the first two days after the injury; often before there has been time for the occurrence of inflammation.

Mr. Erichsen's table contains sixteen such cases, and my own, nineteen; i. e. thirty-five, out of 125 cases in which post-mortem examination was performed, had died on the first or second day of the injury: but as the great majority of those who are thus 'burnt to death' are not examined, we may be sure that the true proportion is much greater than this. Thus, in the same period (sixteen years), during which the seventy-five cases above referred to occurred, 119 other fatal cases of burn were brought into St. George's Hospital, which, by order of the Coroner, were not examined after death; of these seventy-nine died in the first period, twenty-six in the second, and fourteen afterwards. The cause of death in the large majority of these cases is shock; a somewhat vague term, which has been variously interpreted by different authors. Dupuytren imagined that death, in the early period of burns, is produced frequently by excess of pain,* and thus explained the occurrence of death by shock; but this explanation can hardly be considered as worth much, since it leaves us as much as ever in the dark as to the mode in which death is brought about. It seems more natural to attribute the fatal result to the disturbance of the internal circulation, produced by the sudden check to that through the superficial vessels. Congestion of the brain and mesencephalon, among other viscera, is thus produced, which manifests itself in a suspension of the functions of those great nervous centres.† This view derives all the confirmation which anatomy can give it, from the fact, that some unnatural congestion of the brain is always, or almost always, found in examining the bodies of those who die at this period. Of Mr. Erichsen's sixteen cases, 'the brain and its membranes were found congested, with more or less serous effusion into the ventricles, or arachnoid, in fifteen cases.' The other was not examined. I have not myself found this appearance quite so uniformly, but the results of my table are sufficient to give a general support to Mr. Erichsen's views, as in those cases where the brain was examined (unfortunately only very few), I find only one in which it is asserted to have been healthy in respect of structure and vascularity. Congestions of the other viscera are also very common, or rather, internal congestion is probably always present, although it is not always possible to recognise this condition by post-mortem examination. Thus, of Mr. Erichsen's sixteen cases, thoracic congestion was noted in eight, and in six of my nineteen cases; while the congestion had passed on to demonstrable inflammation in one of the former, and in three of the latter: or, in general language, there were traces of thoracic congestion in one-half of the cases examined. Those who have observed how frequently the tissues (and more especially the mucous membranes) lose after death all traces of the congestion, which we know from infallible signs to have existed during life, will not hesitate to admit from this evidence that there is a great tendency to congestion of the thoracic viscera in every case of severe burn. Of course this tendency becomes more formidable in proportion as the burn approaches nearer to the situation of those viscera. Congestion of the abdominal organs is less frequently met with, although by no means uncommon, since twelve out of Mr. Erichsen's cases displayed this condition. Among my cases, however, it is noted in only three instances; but in one of these it had advanced to such an extent as to produce extravasation beneath the mucous membrane of the cæcum.

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* Op. cit. p. 518.

† See Erichsen, loc. cit.

Another extremely common seat of congestion is in the mucous membrane which lines the pharynx and larynx. This is, no doubt, at least in the great majority of cases, the result of the inhalation of flame or heated air during the accident. Of the nineteen cases in my table which died during the first period, only six wanted some appearance of congestion in this part. The congestion in the pharynx very generally ceases abruptly at the commencement of the œsophagus; in some rare cases, however, it extends into the stomach. It frequently gives rise to inflammation and effusion in the submucous tissue about the fauces; but I do not find among my notes much reference to symptoms dependent upon this condition, except an occasional notice of dysphagia, and it is of subordinate importance.

Not so, however, the same condition in the larynx, which often co-exists with the congestion of the pharynx. This is very apt to produce œdema glottidis, spasm of the glottis, and all the fearful consequences which follow such spasm. Nine out of my seventy-five cases presented traces of inflammation of the larynx, which in three of them seemed to have been the sole cause of death. In the scalds of the glottis, to which children are so liable from inhaling hot water or steam from the spout of a kettle, this condition inevitably occurs, and is very fatal. If emetics and the moderate use of antimony with or without calomel do not very shortly improve the state of the breathing, laryngotomy is the only resource; one which too often proves unavailing. The reader will find this point more fully treated under the head of INJURIES OF THE NECK. Besides these nine cases, three died of inflammation seated lower down in the trachea.

So much for the post-mortem appearances in the first period. What indications are to be drawn from them? The existence in all the most important viscera of extreme congestion, which passes on very rapidly to inflammation,* may be, and has been, taken to be an indication for so-called 'antiphlogistic' measures; and accordingly we hear of bleeding from the jugular vein to obviate cerebral inflammation; of leeches, to prevent abdominal complications; of bleeding from the arm, to guard against pneumonia; of mercury, tartar-emetic, and low diet. Now, without going so far as to assert that cases may not occur in which such measures may be useful in the period of inflammatory reaction, I believe that the theory which would recommend them in the first stage of the injury is an erroneous one. The congestion is due to the sudden revulsion of blood from the surface, by which the heart is oppressed, and the stagnation thus perpetuated. The congestion, in a word, is passive. To remedy this mechanically, by taking blood out of the veins, is, I believe, impossible; and, indeed, the state of prostration in which the patient is always found is such, that I never saw a case in which any such proposal was made. Nor is any reduction in the mass of the blood desirable, since the patient will soon be in a condition in which he will require all his strength. Diffusible stimulants afford, I believe, the means most likely to succeed in arousing the powers of the circulation, and restoring the succession of those vital changes in the great nervous centres on which the patient's chance of surviving depends. The depression, coldness of the surface, and sinking, should be combated by warmth to the surface, generous diet, and small but frequently-repeated doses of alcoholic stimulants and ammonia. These must of course be given cautiously, since sthenic inflammation of the thoracic viscera may supervene; but they may be pushed till the strength of the pulse rises to the standard of health; and as it does this, its frequency will probably be found to diminish. Opium is of great service in the period of pain, terror, and depression which follows severe burns in adults, and may be given liberally. In children, in whom the tendency to congestion of the brain is so marked, it should be used cautiously, if at all.

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* I have notes of several cases, in which effusion of lymph was found on the day after the accident.

Pathology of the second period.—The second period is more peculiarly that of inflammation, and is usually held to commence at the end of the second day, and to extend to the end of the second week. During this period, twenty-nine out of my seventy-five cases died, and twenty-five out of Mr. Erichsen's fifty; or fifty-four cases out of 125. The visceral affections at this period are principally of the brain and lungs, and intestines, since the cases in which the larynx is injured usually die earlier. Of Mr. Erichsen's twenty-five cases, the brain was affected in fourteen; eleven being simple congestion,* and three serous effusion. Of my own twenty-nine, the brain was left unexamined in the great majority; and this, I conclude, was in consequence of the absence of cerebral symptoms. Three, however, are noted, in which the occurrence of convulsions or obstinate vomiting drew attention to the brain. It was found congested in all, with effusion of fluid into the ventricles, or arachnoid; but there was no evidence of true inflammation in any case.

The lungs are more frequently affected. Thus, in Mr.

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* I may remark that, in the absence of notes of the symptoms during life, no great importance is to be attached to the mere record of 'congestion' of the cerebral vessels after death. Hardly any post-mortem appearance is so variously estimated.

Erichsen's table the lungs were congested in ten cases, and inflamed in five. Out of my own twenty-nine, inflammation of the lungs or pleura had occurred in seven cases (in one, however, it was believed to have existed before the accident), and congestion is noted in five others.

The lesions of the abdominal organs are of extreme interest, on account of the singularity of the appearances which they present, and the physiological speculations to which they give rise. They are entirely confined to inflammatory phenomena in the gastro-intestinal tube. None of the other abdominal viscera (liver, spleen, or kidneys) are, as far as I have observed or can discover in authors, ever affected as a consequence of burns except in pyæmia. The inflammation of the intestines rapidly passes on to ulceration of the mucous coat, and is so generally limited to the duodenum, that little attention has been paid to lesions of other portions of the intestines or of the stomach, although they do sometimes occur. The earlist period at which I find notes of ulceration of the duodenum is in one of Mr. Erichsen's cases on the fourth day. In my own table, two cases are noticed on the fifth day, and one on the sixth. The whole number of cases in which ulceration of the duodenum was discovered during the second period was, out of Mr. Erichsen's twenty-five, six; out of my twenty-nine, four; to which two ought to be added, in which, though the duodenum was intact, extensive ulceration was found in other parts of the intestine. This gives twelve cases in the second period out of fifty-four. The duodenum in three other of my cases presented enlarged glands; and in one of these the enlargement affected also the glands throughout the whole intestinal tract. Congestion is also frequently found; but its pathological importance appears slight at this period of the disease. The whole subject of abdominal lesions will be resumed further on, with the pathology of the third period. It will be sufficient for the present purpose to state that of the cases in which ulceration occurred it was unaccompanied by general inflammatory symptoms in any instance; and that where it caused death, that result was occcasioned by hæmorrhage.

On consideration of the symptoms which accompany these inflammations, it must be allowed that they contraindicate the use of active depletion, and that the object of our treatment should be rather to support the patient's strength, and enable him to live through the local action which is probably inevitable.

Care, of course, should be taken not to over-feed or over-stimulate a patient with inflammation of the lungs or bowels; but, in these as in all other cases in which inflammation follows injury, the general treatment should be guided by the general symptoms, and especially by the tongue, the pulse, and the state of the skin; and if the pulse is weak, and the surface cold, stimulants should be prescribed, with generous diet if the condition of the tongue allows of it, even though the patient is known to be affected with thoracic or abdominal inflammation; while in the opposite state of the system it may be proper to pursue the antiphlogistic regimen. The surgeon must be guided in this, as in so many other matters, more by common sense, and a competent knowledge of the principles of his art, than by rule and theory. In the practice of our metropolitan hospitals we have frequent opportunities of witnessing the success of the stimulating treatment, even in cases of acute visceral inflammation; and such treatment has now become common in the hands of many of our best physicians; while in a different air, and among people of a different constitution, the antiphlogistic plan may be indicated, and may prove successful. Experience and tact will decide the question in each case; but there can be little danger in asserting that bleeding, low diet, mercury, and tartar-emetic, are not likely to obviate ulceration in persons of weak constitution and irritable circulation; and that, as far at least as the abdominal complications are concerned, they are more under the control of stimulants combined with opium. The thoracic inflammations are still more difficult to deal with. I have notes of a case in which fatal pleurisy supervened directly after, and very probably in consequence of, free stimulation, which nevertheless was necessitated by the general condition of the patient; while, on the other hand, my notes tell of several cases in which, notwithstanding the known presence of inflammation of the thoracic viscera, it was impossible to use depletion on account of the patient's debility. Local antiphlogistic measures, combined with general stimulants, offer the best prospect of success in these difficult, and generally unsatisfactory cases. I have seen instances in which some good seemed to result from the combination of moderate doses of tartar-emetic with the stimulating regimen.

Pathology of the third period.—If we pass now to the third period—that which is called the period of suppuration or exhaustion—we shall find that the causes of death are by no means limited to the exhaustion either of profuse discharge or of protracted suffering, but that inflammation enters largely into the category. As to the proportion of deaths which occur at this period, Mr. Erichsen's table and mine are somewhat at variance, his giving only nine out of fifty, less than one-fifth, mine twenty-seven out of seventy-five, more than one-third.

The lesions of the brain which are met with at this period are not very important, and are in fact, so to speak, accidental, being limited almost entirely to cases of infantile convulsions and pyæmia. I shall therefore dismiss them, as requiring no special consideration.

The chest is more frequently affected, and this affection is a very frequent cause of death. It occurs chiefly when the injury has affected the walls of the thorax. In Mr. Erichsen's table, lesions of the lungs and pleura are noted in six cases out of nine. In four the appearances were distinctly inflammatory, and in the two others there was congestion, with effusion into the pleural cavities. In my collection, out of twenty-seven cases, morbid appearances are noted in the lungs in ten; and in eight of these the inflammation, if not the sole, was at any rate a principal cause of death. The diagnosis of the presence of thoracic inflammation is not always easy, since the burn is usually situated on the chest, and precludes the possibility of physical examination; but hacking cough, bloody sputa, or pain in the chest, will direct attention to the lungs or pleura, and set the surgeon on his guard. The indications for treatment, however, are perplexing in the extreme, since weakness is a more prominent feature than in the second period. Indeed, all means of treatment will usually fail, and the cases must be looked upon as almost hopeless.

Lesions of the abdominal viscera are frequently met with during the third period of burns. Out of the twenty-seven cases in my table proving fatal during this period, there were six in which open ulcers were found in the duodenum, one in which a similar ulcer was found cicatrised, one in which the whole mucous membrane of the small intestines was found inflamed, but not ulcerated, and one in which the duodenal glands were found enlarged. Mr. Erichsen, however, found no instances of ulceration of the intestines among the nine cases in his table.

Intestinal ulceration is a sufficiently common phenomenon in every period of burns and scalds. Of the 125 miscellaneous fatal cases from which this account has been compiled, sixteen presented ulceration in the duodenum, five of which died during the first week (four days being the earliest period), five in the second week, and the other six after longer periods, one as late as the seventy-fifth day. The patients' ages varied as much as the period of death: four were children of the ages of 5 or 6, two young adults 19 and 27 years of age; two in the middle period of life, 37 and 42 years old; and two aged persons, 66 and 78 years of age. The situation of the burn was very various. In two cases the extremities only had been burnt; but in all the rest some part of the trunk (chest or abdomen) had suffered. The appearance is that of a perfectly indolent ulcer; it is usually seated just below the pylorus; often there are two or three close together; the edges of the ulcers are not raised nor everted; there is little or no evidence of vascular action or inflammatory effusion in their neighbourhood; when they are recently formed, they look simply as if a portion of the mucous membrane had been cut out. But when the ulcer has penetrated more deeply, so as to threaten perforation of the gut, lymph may often be found effused on its peritoneal surface; a natural barrier, apparently, to the fatal progress of the disease. Sometimes the glands of the duodenum may be found enlarged; but though this appearance is sufficiently common in all cases of burn, it does not appear that it is at all a constant accompaniment of those in which ulceration exists. It has been assumed rather than proved, that the enlargement of the glands is the first step in the ulceration. It is quite possible that it may be so; and the theory, which was first broached by Mr. Curling,* on the suggestion of Mr. Bowman, is, that the strain thrown upon the intestinal glands, especially Brünner's, in separating the watery material out of the blood which accumulates in it from the suspension of cutaneous perspiration, is the cause of the diarrhœa and ulceration. This is the only rational explanation yet offered of the pathology of this lesion; but it is purely conjectural.

If we inquire into the symptoms of ulceration of the duodenum, we shall find the results principally negative. In the large number of cases which are comprised in these tables, and which have been observed by persons sufficiently competent and careful,* I can find no evidence that the *accession* of this ulceration is announced by any unmistakable symptoms. No pain appears to be complained of in the part, nor is it noticed that the region of the duodenum is tender to pressure. Diarrhœa is not constantly present, nor when present is it by any means decisive of the point. Vomiting does indeed frequently occur in the early stage of ulceration of the duodenum, but it is as often symptomatic of cerebral as of intestinal or gastric irritation. We are therefore left, to a great extent, in the dark as to the early symptoms of this affection; and all that we are entitled to say upon the subject is, that the occurrence of obstinate diarrhœa and vomiting should always direct our attention to the stomach and duodenum; that careful palpation of this region may sometimes assist our diagnosis; and that the presence of blood in

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* *Med.-Chir. Trans.* vol. xxv.

FIG. 6.

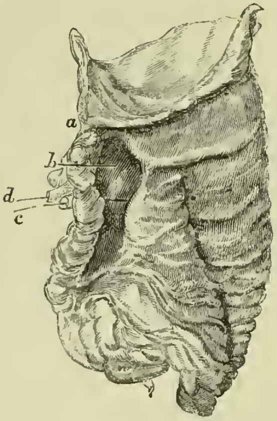
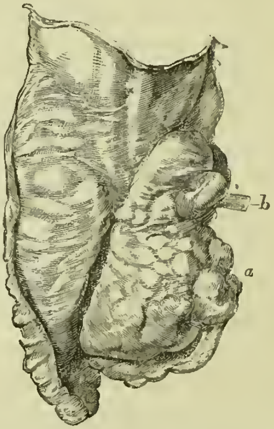


FIG. 7.



Ulceration of the duodenum in a burn, causing death by hæmorrhage from a large branch of the pancreatico-duodenalis artery.

Fig. 6.—Internal view.—*a.* The pylorus.
b. The ulcer on the duodenum close below the pylorus.
c, d. Bristles passed through the artery and vein, which are seen to open freely on the ulcer.

Fig. 7.—The opposite view of the same preparation.
a. The pancreas.
b. The artery which was ulcerated.

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* The notes in my cases were taken by myself for five years, and by the other Hospital Registrars for the time being. In Mr. Erichsen's table the authorities are given.

the evacuations is strongly confirmatory of it. When the severe symptoms, which are occasionally noticed, come on, intense pain, copious hæmatemesis or melæna, distension of the abdomen, rapid sinking, we may be sure that the ulcer has proceeded to perforate either the peritoneal coat of the gut, or some considerable vessel (probably the pancreatico-duodenal artery), and that the case is beyond the reach of remedies. The accompanying figures are from a preparation in the Museum of St. George's Hospital (Series ix. No. 142), showing a large branch of the pancreatico-duodenal artery opened close to the parent trunk by an ulcer of this nature.

The diagnosis, then, of intestinal ulceration being so obscure, what is the prognosis? It was supposed, when this complication was first pointed out, that it was necessarily fatal; but that this supposition is erroneous is proved by the records of cases in which such ulcers have been found cicatrised. Mr. Curling gives one such case;* and my notes contain another. In the latter instance, the patient, a child æt. 3½, died on the twenty-eighth day after a severe burn on the chest, arms, and thighs. The proximate cause of death seems to have been pneumonia, combined with exhaustion from suppuration and diarrhœa. A circular patch about the size of a fourpenny piece was found at the commencement of the duodenum, where the mucous membrane was deficient, and the exposed surface cicatrised. It is interesting, as showing the uncertainty of diarrhœa as a symptom in these cases, to notice that here it occurred for the first time on the twenty-third day, when the ulcer must have been nearly, if not altogether, healed. From the facts, then, that cicatrised ulcers are sometimes found in patients who have died of other complications; that the lesion does not of itself produce any symptoms of dangerous disturbance of the health; and that it is frequently discovered in cases where it would never have been suspected, I am inclined to think that it may be present in many of the cases which recover, and that its importance in practice has been exaggerated.

Other parts of the intestines are sometimes, although rarely, affected. My table contains only one case in which the jejunum and ileum were ulcerated, the duodenum being intact. Peritonitis was not associated with it in any case. When the serous membrane is affected, it is always, as far as I can see, the result of local irritation from burn of the abdominal parietes, and affects the low purulent form, rather than the adhesive.

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* *Medico-Chirurgical Transactions,* vol. xxv. p. 280.

Thus it will be seen that all the inflammatory phenomena connected with the lesions of the intestines belong to the class of low inflammations; that they are not ushered in by any of the local or general symptoms which accompany acute disease; and that when they prove fatal, it is by the secondary consequences of the ulceration (perforation or hæmorrhage), and not from any interference with the function of the gut, nor any impression on the general health.

It may seem absurd to talk about the treatment of an affection which, generally at least, eludes diagnosis. Still, as the frequent presence of ulceration in the intestine has been made a pretext for recommending a more active antiphlogistic regimen in burns, it is right to point out that a more attentive consideration of the question would have shown that the indications are all the other way. If the insidious progress of a duodenal ulcer can be stopped by any remedies before it has opened the pancreatico-duodenal artery or perforated the peritoneum, it must assuredly be by some means different to those which may be used successfully in preventing plastic exudation or restraining vascular action. It is hardly likely that reducing the patient's already exhausted powers can have any other effect than to hasten the progress of the ulceration, and add fresh victims to that 'majority' which already owes so much to the 'nimia medicorum diligentia.' In all stages, then, of the treatment of burns, great caution should be exercised in the use of antiphlogistics; and the only period in which they are admissible at all, unless in very exceptional circumstances (such as some instances of scald of the glottis), is during the second period, in thoracic inflammation; and even there, as has been said before, it will be generally found impossible to press the treatment.

Local treatment.—The local treatment of burns is a subject on which many books have been written, and perhaps more numerous remedies recommended than in any other branch of surgery. The success which is said to have attended very different, and even opposite, modes of treatment shows that the authors must either be misrepresenting the facts or speaking about different matters. I prefer the latter explanation, more especially as I find that authors who have written to recommend certain methods have almost invariably spoken of burns as if they were all alike, forgetful apparently that the essential question in the local treatment of a burn is its depth, or degree, and the consequent probability of sloughing, ulceration, or mere inflammation resembling that of erysipelas. It is only by keeping this point steadily in view that we can hope to arrive at any rational plan for the treatment of these injuries.

1. First degree. In cases of burns of the first degree, little local treatment is necessary, except to keep in contact with them any application which will relieve pain and exclude the air: if, at the same time, it tends gradually to constrict the vessels of the skin, dilated by the sudden stimulus, so much the better. Cold applications are usually more agreeable than warm, lotions than ointments. In hospitals, the usual application is Goulard-water on rags frequently irrigated; cold water does very nearly as well; but a host of remedies are in domestic use—scraped potatoes, ink, moist earth, &c. &c., all of which act on the same principle.

If, however, the burnt surface is very extensive, and the patient is much depressed from fright or pain, it would be injudicious to chill the surface further by cold applications; and then it will be better to wrap the part in cotton-wool, or powder it thickly with flour, or to use some of the stimulating substances which will be enumerated further on. The new epidermis is formed usually in two or three days, after which no further application is required. The vessels of the skin, however, will remain dilated for some time, as they do after a blister.

2. In the second degree, the principles and details of the treatment are very much the same as in the first, except that care must be taken to preserve the epidermis. It is often (especially in extensive scalds) raised from the skin in very large blebs filled with serum, which adhere to the clothes, particularly when the latter are sodden in water, and are then generally dragged off by the patient's friends in undressing him. This, however, ought always to be avoided when professional aid is early at hand; the clothes should be very carefully cut off, the bullæ opened by a small puncture, and the epidermis smoothed down gently upon the skin. It will, if carefully managed, generally remain there till the papillæ are protected by a fresh formation. When the burnt surface has been deprived of its epidermis, the papillæ usually furnish an abundant secretion of pus, and are distressingly irritable and sensitive. Sometimes the papillary

tissue may slough from the resulting inflammation, even in cases where it is in no degree disintegrated by the injury. In other respects, the treatment is the same as in burns of the first degree; the best plan, perhaps, being to apply some mild salve (such as calamine cerate) over the burnt surface, and then to wrap the part thickly in cotton-wool.

3. Burns of the third degree are much more serious than the two former varieties of the injury, since here a portion of the papillary tissue has been destroyed, and must slough; and its reproduction, if the extent involved be great, is usually a very tedious process, while during its progress the patient is of course liable to the various complications which may affect any open wound (erysipelas, phagedæna, &c.), as well as suffering from the weakness induced by protracted discharge. The best way of treating burns of this depth, is to dress the sloughing parts with some stimulant application, in order to hasten the separation of the slough. The best with which I am acquainted is the ung. elemi co. of the St. George's Hospital *Pharmacopœia*.[*] Or turpentine may be used in liniment, or mixed with an equal quantity of this ointment. Turpentine is a very valuable application in burns where the surface is sloughy, but is unnecessary and painful in those where it is raw and tender. Carron-oil (a mixture of equal parts of linseed-oil and lime-water) is a deservedly popular remedy; and hosts of other stimulating substances are recommended. I have lately used in several cases, and I think with very good effect, the mixture of carbolic acid and linseed oil, so highly recommended by Mr. Lister in the treatment of various injuries. Professor Pirrie also speaks highly of its use in burns.[†] The oil should be in the proportion of six to eight times the quantity of the acid. It seems to allay pain and obviate fœtor better than any other application. The neighbouring part, where the burn is less deep, may be dressed with some mild ointment; and the whole enveloped, until reaction is thoroughly established, in a thick layer of cotton-wool, loosely supported by a bandage. The dressings of a burn should never be changed more often than is absolutely requisite for cleanli-

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[*] ℞ Unguent. elemi ℔j.; unguent. sambuci ℥ij.; copaibæ ℥iij. Unguentis simul liquefactis et ab igne remotis, paullo antequam refrixerint, copaibam adjice.

The unguentum sambuci is another hospital preparation made of the leaves, in the proportion of 2 lbs. to 2½ lbs. of fat boiled down with water and strained.

[†] *Lancet*, Nov. 9, 1867.

ness. As the slough loosens at the edges, its loose part should be cut away at each dressing; but it must not be forcibly detached. When it has separated, the exposed surface is left raw and suppurating; generally indented by small pits, from the unequal depth of the slough. The object now is to procure cicatrisation as speedily as possible, since, if the inflammation proceeds unchecked, a crop of prominent, flabby, or fungous granulations will spring up, which are with difficulty brought to heal; or ulceration may proceed at the edges, and widen the sore. I believe the best plan will be to apply moderately firm pressure, as soon as it can be borne, by careful strapping. If the diachylon plaster be found too irritating, soap-strapping may be used, or the plan recommended by Mr. Chapman for ulcers of the leg (water-strapping). I believe, however, that adhesive plaster is the preferable material, and its use affords by far the most efficient and comfortable plan of treating large granulating burns. The strapping is not extremely painful at the time of application, does not require frequent removal, and does not necessitate confinement to bed. If this method be contraindicated, the sore must be treated on the general principles laid down in the essay on Ulcers; but it will be found almost inevitable to recur to pressure in some form, when the granulations have sprouted up and present an extensive suppurating surface, which shows no tendency to heal. Such cases go on for months under every kind of treatment, even when the granulations look healthy. Sometimes the sore, after being healed for a shorter or longer period, will break out again from time to time; occasionally it remains incurable. In recent cases, repressing the granulations by pencilling either the edges, or, if necessary the whole surface, with stick-caustic, and applying firm pressure with strapping, is the most efficient method of treatment. Sometimes it will be advisable to fix on to the granulating surface below the strapping a piece of thin sheet-lead, or of oiled-silk, cut so as to fit the wound exactly; and it is frequently found beneficial, especially when the discharge is profuse, to dust the surface with some astringent, in fine powder, as starch, alum, calamine, &c.

It is the opinion of some surgeons* that in burns which suppurate extensively, death is often due to the mephitic influence of the foul air which is so extensively generated in such injuries. In these cases, no better application can be used than Condy's ozonised liquid, diluted in the proportion of from half a drachm to a drachm in a pint of water. This excellent disinfectant is now in very extensive use in all cases of foul discharge or fœtid exhalation. It has also appeared to me to exercise a favourable influence on the progress of the indolent ulcerating surfaces of burns, apart from its disinfectant action; and thus I employ it frequently as a topical application to burnt surfaces in children.

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* See a Clinical Lecture, by Mr. Mitchell Henry, in *Lancet*, Dec. 19, 1851, p. 580.

4. The above observations will also apply to the treatment of burns of the fourth degree; but here a most important additional element enters into consideration, that of the contraction which will accompany and follow cicatrisation. Those who have had even slight practical experience of these cases, need not be reminded of the frightful deformities thus induced: the head drawn down upon the shoulder, the jaw everted and fixed upon the breast, the lips turned out, clear articulation impossible, the dripping and distorted mouth, the rigid twisted limbs, and all the ghastly and hopeless mutilations which so often follow burns in the neglected children of the poor. Whenever, therefore, there is the slightest probability that the whole thickness of the skin has been involved in any part of a burn, cicatrisation ought to be watched with the greatest care, especially if it be in a part where the integuments are loose, and where important organs would be interfered with by contraction, in order to obviate this result as far as possible, by the use of appropriate extending apparatus. This apparatus should be very carefully fitted, and maintained night and day in position till the burn has healed; and for some time afterwards, as the tendency to contract does not vanish with the healing of the wound. As long as any risk of contraction seems to be present, the scar should be kept stretched, and its extensibility be promoted by keeping it constantly saturated with oil. The ingenuity both of the surgeon and instrument-maker is called for in these cases, and much success is often obtained both in obviating and curing deformities. But many disappointing and hopeless cases will be met with, in which the use of extension cannot be tolerated on account of the pain and irritation it causes, or in which the patient's strength is so exhausted that he cannot bear the extra call upon it, which is of course necessitated by keeping the wound largely open; or in which the points where

counter-extension should be made are themselves involved in the injury. In these we must allow contraction to occur, and only think for the moment of producing as speedy union as possible; or if a limb be the seat of the injury, and the resulting contraction will leave it useless, the first favourable moment for amputation must be chosen. The treatment of contracted cicatrices will be found described elsewhere (PLASTIC SURGERY).

Little need be added as to the treatment of burns of the fifth and sixth degree. The former, if of any considerable extent and seated on the trunk of the body, are almost necessarily fatal. When the limbs are the seat of injury, and the part involved is large, or when the fingers are burnt, and the consequent sloughing will destroy the action of the tendons and render the finger useless, it is better to amputate at once. Burns of the sixth degree, if the patient survive so as to become the subject of treatment, must be seated on the extremities. Practically they are hardly ever seen, except where the thickness of the soft parts is trifling, as on the fingers, dorsum of the hand or foot, &c. Most of them require primary amputation; the necessity depending on the extent of the burn, and the conditions which will follow the separation of the sloughs.

It is hardly necessary to say anything about the indications for secondary amputation in burns on account of incurable ulceration, or contraction of the limbs, as these are questions rather of common sense than of precedent or theory; and where large joints are opened by the separation of the slough, the case does not differ materially from any other of gangrene with similar complication.

ACCIDENTS FROM LIGHTNING.

Accidents from lightning are very rare in this country,* and it has never fallen to my lot to witness immediately on their occurrence any which called for serious surgical treatment; nor does it seem to have occurred to those of our countrymen, whose experience of this form of injury in tropical climates may have been greater than ours, to give the profession any systematic account of the matter. I must therefore apologise for the necessarily secondhand character of what follows on this head. Sir Benjamin Brodie, in his *Lectures illustrative of various Subjects in Pathology and Surgery*, has treated the subject with his usual clearness and felicity; but only so far as to show the manner in which death is produced by a stroke of lightning, and the means to be used in order, if possible, to save life. The most complete account which I have been able to find of the minor, but still very serious, symptoms which sometimes follow these injuries, is contained in Boudin, *Géographie médicale*, Paris, 1857, vol. i. pp. 499 et seq. An abstract of M. Boudin's researches may be found in Althaus, *Medical Electricity*, London, 1859, Appendix. From these sources and from a number of cases recorded in old volumes of the *Philosophical Transactions*, the following account has been chiefly compiled.

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* M. Boudin calculates the number of deaths in England at twenty-two per annum; and the total of accidents at about double this number.

A person struck by lightning is usually more or less completely deprived of consciousness at the time. This is a consequence sometimes of the shock given to the brain, and is accompanied by more or less paralysis of motion and of sensation, common or special. Sometimes, and perhaps more usually, it is the effect merely of fright, and is then only transient. The insensibility sometimes lasts for a considerable time; as in a case recorded by M. Boudin, in which a gentleman having been struck by lightning remained for an hour and a quarter without (as the bystanders affirmed) any sign of life, and then recovered on being exposed to a pelting shower of hail. The paralysis by which it is usually accompanied may last for an indefinite period. In the above case the patient did not entirely recover for more than four months; and in one recorded in the sixty-third volume of the *Philosophical Transactions*, weakness and numbness were still felt three months after the stroke. This paralysis is more common in the lower limbs than the upper. Other affections caused by lightning are: burns, more or less extensive; eruptions of erythema or of urticaria, which are said by one author to have reappeared afterwards with each succeeding thunderstorm; loss of hair over parts or the whole of the body; wounds; hæmorrhage from the mouth, nose, or ears; loss of sight, smell, speech, hearing, and taste, or, in rare cases, exaltation of these special senses; cataract; imbecility; abortion. Another curious effect of lightning, which is asserted by many independent authorities, though it is variously interpreted, is that it sometimes leaves arborescent marks on the body, even on parts covered by clothes, which have often been described as a kind of photograph of neighbouring trees or other objects.

Many of the recorded cases of injury by lightning are very curious and interesting; but, as the foregoing list will show, the symptoms are too miscellaneous, and their method of production too obscure, to be brought under general rules; and it would lead us too far from ordinary practice to attempt to dwell minutely upon them. It may suffice to say that persons not killed on the spot usually recover, though a few cases are on record in which they have died of exhaustion; and that recovery is apparently hastened by the administration of tonics, especially quinine, and gentle action on the skin by means of baths. In the case of protracted convalescence already referred to, the patient on coming to himself found that he had completely lost the sense of sight, and that he could hardly feel any of his limbs, and could not move them. He was also severely burnt on various parts of the body. In this case, as the power of motion and the sense of sight returned, the patient was tormented with pains in the limbs and head. These were relieved by galvanism, which was thought also to have hastened the healing of the sores left by the burns. The loss of hair, which is sometimes produced by the action of lightning, is a phenomenon more commonly noticed in the lower animals, who, it may be remarked, are much more exposed to damage in thunderstorms than human beings, even under the same circumstances. Sir B. Brodie has referred to a curious story, in the *Philosophical Transactions*, of two bullocks, pied white and red, who were struck in different storms. In both cases the white hairs were consumed, and the red escaped. The following anecdote, however, related by M. Boudin, shows that in men also loss of hair is sometimes produced by flashes of lightning. The frigate *Golymin* was struck by lightning on the night of February 21, 1812, and the captain, M. Rihouet, received several wounds on the head. 'The next day,' says that officer, 'when I went to shave myself, I found that the beard, instead of being cut, was torn out by the action of the razor; and since that day it has totally disappeared. The hair of the scalp, eyelashes, eyebrows, and surface of the body fell off successively. Since then I have remained entirely hairless. During the year 1813, the nails of my fingers scaled away. Those of the toes experienced no visible change.'*

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* *Œuvres de F. Arago*, Paris, 1854, tom. i. p. 377.

The burns caused by lightning are sometimes deep and very obstinate in healing;[*] sometimes, on the contrary, they amount merely to vesication, or even only to discoloration. They will be treated on ordinary principles, unless indeed the authority of the case above alluded to should induce the surgeon to make trial of the effects of electricity, which is said sometimes to produce the healing of ulcers due to other causes, which have resisted the ordinary modes of treatment.

Mutilations of the body are only rarely met with. Out of a large number of fatal cases, M. Boudin has only found six in which mutilation is noticed to have occurred; and it is a singular circumstance that in four of these the tongue was the part affected. Wounds and fractures, especially of the skull, are sometimes, but rarely, noticed.

The post-mortem appearances in cases of death by lightning vary extremely. The body sometimes retains the attitude in which it was when struck. Thus a case is related in which a man was killed on horseback, and the horse proceeded some distance with the dead rider still in the saddle. At other times the body is thrown to a considerable distance. The clothes are often burnt or torn, even when the surface of the body is not injured. In respect of muscular rigidity, opinions, and probably facts, vary also. John Hunter taught that 'animals killed by lightning, and also by electricity, have not their muscles contracted;'[†] but this is certainly inconsistent with common experience, although it may be the fact in exceptional instances. Thus in Dr. Richardson's work on the *Coagulation of the Blood*[‡] may be found the account of an experiment performed on a large dog, which was killed by a powerful electric current. In half an hour rigor mortis commenced, and increased to such an extent that 'in five hours the dog appeared as if frozen hard,[§] or carved out of wood, being quite stiff and inflexible.' The same author (p. 138) makes death by electricity the only exception to the rule that in cases of immediately sudden death the blood coagulates 'with moderate firmness and in the ordinary mode.' To the same effect is a case reported in the *Philosophical Transactions*, vol. lxiii. p. 177, where a man was struck dead while in bed. A doctor was sent for, who, at the request of the patient's wife, opened a vein in the arm. The blood was so fluid that it continued to ooze out till the man was put in his coffin. M. Boudin, however, says that the blood is sometimes found coagulated; and Sir C. Scudamore's experiments prove the same fact in animals killed by electricity.* The heart is usually, as it seems, flaccid and empty. The condition of the lungs seems very uncertain. Putrefaction may be sometimes hastened, but is more often retarded.

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[*] Cases are reported in which the entire bodies of men and animals have been reduced to ashes; but such events (if indeed they be not mere exaggerations) must be very rare.

[†] *Works*, by Palmer, vol. iii. p. 114.

[‡] Astley-Cooper Prize-Essay, p. 96.

[§] This may account for the fact, that persons killed by lightning have sometimes been described as presenting all the appearances of having been frozen.

Death is caused in immediately fatal cases by the shock to the brain and nervous system, and perhaps in some rare instances by asphyxia; and it appears impossible to express the indications for surgical treatment in these cases more clearly and succinctly than they are thus given by Sir B. Brodie: 'Expose the body to a moderate warmth, so as to prevent the loss of animal heat, to which it is always liable when the functions of the brain are suspended or impaired, and inflate the lungs, so as to imitate natural respiration as nearly as possible.'† It may be added that these attempts to restore animation should not be too soon given up, since stories are on record (one of which has been quoted above) of the return of animation after its apparently complete suspension during more than an hour. Cold affusion, stimulating enemata, and stimulants administered by the mouth, will be appropriate adjuvants to this treatment, especially in the less severe cases. The prognosis is generally favourable, as far as the recovery of life goes, in cases not instantly fatal; and even when some of the special senses are temporarily abolished, their restoration is not hopeless.

TIMOTHY HOLMES.

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* Taylor's *Med. Juris.*, art. 'Lightning.'

† Op. cit. p. 104.

FRACTURES.

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FRACTURE may be defined to be a sudden, violent solution of continuity of a bone.

Causes.—The causes of fractures are of two kinds: predisposing and determining. The predisposing causes are certain natural agencies, viz. the age and sex of the patient, and the liabilities of different bones. Some morbid conditions of the bones, which render them unusually fragile, are also commonly included under this title, though in such cases it is more correct to regard the fracture as an accidental accompaniment of the primary disease.

The influence of age goes nearly hand-in-hand with the liability to exposure to the external causes. The smallest number of fractures is found in infancy, especially between the ages of four and five. At puberty, and again at the age of twenty-five, there is a sudden rise in their ratio; thence the increase is small, but gradual, up to the age of sixty, beyond which the proportion is stationary. The increase after forty must be ascribed to the changes in the bony tissue which occur at that period of life. Certain fractures may be considered the peculiar appanage of old age; as fracture of the neck of the femur, or of the lower end of the radius.

As might be expected, men are much more liable to fractures than women, except in early infancy and in extreme old age. The differences in the development and decay of the skeleton sufficiently explain these exceptions. There are also wide differences in the liabilities of different bones, depending on their form, position, functions, and structure; the long bones suffering most, especially those which are most exposed to the violence of falls.

The morbid conditions of bone which predispose to fracture are either confined to the bone itself, or are parts of a general cachexia. Of the former kind are atrophy, caries, necrosis, chronic inflammation, tumours of all kinds in the bone, and ulceration in consequence either of the pressure of an aneurism or tumour external to it, or of the spreading of an ulcer from the soft tissues.* In all these cases the fracture is to be regarded rather as a complication of the more formidable disease. The general predisposing affections mentioned by authors are scurvy, cancer, gout, syphilis, scrofula, rickets, fragilitas and mollities ossium.

Scurvy does not appear in general to have any injurious effects on sound bone, though in one case Bérard found the bones of the lower extremity congested and fragile.† Numerous instances have been met with of unusual fragility in cancerous subjects; but in all (with, perhaps, one only exception, mentioned by Rumpelt ‡) nodules of cancerous deposit have been found embedded either on the surface or in the interior of the bone.

Gout and rheumatism have been imagined, rather than proved, to weaken the tissue of bones. Not so, however, with secondary syphilis. M. Donatus mentions the case of a syphilitic patient in whom very slight exertion produced a fracture, at one time of the right humerus, at another of the left.§ Since that, many cases of the kind have been recorded. In two of B. Bell's patients the thigh-bones were broken by a slight force; and Brodie has seen the clavicle give way at the seat of a node.

But the disease which, more than any other, predisposes to fracture is unquestionably rickets, or its later type, fragilitas ossium. M. Guersant states, that out of a mean of eighty annual cases of fracture in early life, he has found about one-third in rickety children.|| These cases are of two classes. In some, as in most of those described by Dupuytren,¶ fracture is preceded for some days, or even weeks, by bending, and union is tardy. In others fracture occurs suddenly and repeatedly from the slightest causes. Gibson had under his observation a youth who at the age of nineteen, had suffered twenty-four fractures, eight of which were in the clavicle.** Arnott gives the history of a girl who, between the ages of three and fourteen, had thirty-one

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* *Trans. of Path. Soc.*, vol. x. p. 234.

† *Dict. de Méd.* en 30 tomes, 1836, art. 'Fracture.'

‡ *Gaz. médicale*, 1835, p. 641.

§ *De Hist. Med.* lib. v. cap. 1.

|| *Clin. des Hôpitaux des Enfans*, sixième année, p. 28.

¶ *Extrait d'un Mém. sur quelques cas particuliers de Fractures, etc.*, in *Bull. de la Faculté de Méd.* 1811, p. 156.

** *Institutes of Surgery*, vol. i. p. 370.

fractures, all of the long bones.* Analogous cases are recorded by Tyrrell† and Lonsdale; ‡ and Esquirol possessed the skeleton of a woman, in which the traces of more than two hundred fractures, occurring at different periods, could be counted. In all the above cases the general health has appeared good, and union has not been retarded, nay, more, it has been sometimes unusually rapid. Stanley, however, records a case in which no union could be obtained.§

The immediate causes of fracture are of two kinds: external force, and muscular contraction. The former of these is also exerted in two ways: directly, when the fracture occurs at the part immediately subjected to violence; and indirectly (*contre-coup*), when the force applied at one point is transmitted, and causes a fracture elsewhere. Indirect force is probably the most frequent cause, pure muscular contraction the rarest. But in by far the majority of cases the latter co-operates with the more palpable cause, by directly increasing the strain upon the bones, and, still more, by fixing them. Hence the comparative facility with which partial fracture may be produced in the dead body, by direct force, and the great difficulty, or, perhaps, impossibility of effecting, experimentally, any kind of indirect fracture. Hence, too, the comparative rarity of fractures among skaters, and the proverbial impunity of drunkards.

The two most prolific causes of fracture are falls and blows. Although, as a rule, falls produce indirect fractures and blows direct, yet they are by no means uniform in their results. A fall may be, and may resemble in its effects a series of blows, as in the case of a fall from a scaffolding. Nothing, in fact, is more apparently capricious than the effects of falls. Thus, a fall on the sole of the foot may fracture either the os calcis, the tibia in any part of its length, the patella, the femur, the pelvis, or even the cranium. The causes of such differences, as well as of the varieties in the form of fracture, are more or less traceable to the degree of violence of the fall, the position of the individual and of the limb, perhaps to the different strength of the bones in different persons, but especially to the precise muscular action called into play.

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* *Medical Gazette*, June 1833.

† *St. Thomas's Hosp. Reports*, No. 1.

‡ *Prac. Treatise on Fractures*, 1838.

§ *On Dis. of the Bones*, 1849, p. 241.

Neither is there greater uniformity in the mode of operation of these causes. Commonly it is either compression or forced flexion. But in the production of certain fractures torsion has a large share; as in fracture of the fibula and of the ribs, and in fractures of diseased bones during such slight efforts as turning in bed. Traction assists the other causes even in such cases as fracture of the patella, and separation of epiphyses.

The few recorded instances of fracture of the long bones by unaided muscular action can be ascribed solely to violent and sudden flexion. In different cases, the humerus, the bones of the forearm, the femur, clavicle, even the tibia, have yielded during a powerful muscular effort.* It is a generally received opinion, however, that no long bone can be broken in its shaft by the mere contraction of its muscles unless impaired by some morbid change in its structure: an opinion confirmed by the observation of Nicod,† that in most of these cases fracture has been preceded by pains in the broken limbs, and in some instances followed by actual evidences of disease, as abscess or exfoliation. But abnormal increase of the muscular power, as during convulsions, may be sufficient to account for it. The bones commonly fractured by muscular action are the patella, os calcis, and olecranon. The ribs, and even the sternum,‡ have been known to be broken by the violent action of the diaphragm during coughing, but in all probability they were weakened by partial absorption or atrophy.

The cause of a fracture has considerable influence over its subsequent course and results. It is manifest that, as a rule, the consequences of direct are likely to be far more serious than those of indirect force. For not only are the effects on the bone itself more severe, but the soft parts covering the fracture are subjected to the crushing power of the external violence, in addition to those accidents to which they are equally exposed in both classes of fractures from the displaced fragments.

Intra-uterine fractures originate in two ways. In the majority of cases they are associated with manifest deformity of some part of the body. As many as forty-three, and even 112 fractures § have been found in the same fœtus, depending, of course, on imperfect development of the bones, or 'congenital rickets.' But fracture proper, due either to external violence or abnormal muscular construction, may occur in the bones of a healthy fœtus. These fractures have been found in all conditions. They are not unfrequently compound, and have been known to wound the uterus, causing hæmorrhage and abortion.*

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* For a summary of such cases see Cooper's *Surg. Dict.*, art. 'Fracture'; and Hamilton on *Fractures and Dislocations*, 1860.

† *Annuaire méd.-chir. des Hôp. de Paris*, 1819, p. 494.

‡ *Gaz. des Hôpitaux*, mars 1830.

§ Chaussier, in *Bull. de la Fac. de Méd.* 1813, p. 301.

Varieties.—Fractures are divided primarily into simple and compound; the essential character of the latter being the co-existence of a wound in the skin, with which the fracture communicates. This distinction is important; the two great classes of fractures differing from one another in the nature of the process necessary for their repair, and, consequently, in their results and dangers, and the duration of their treatment. There are two ways in which the wound may be produced at the time of the accident: from without, by the same direct force which fractures the bone; or from within, by the end of one or both fragments being thrust through the soft parts, whether by the continuance of the original force, or by the weight of the body. The latter mode is the more frequent of the two; and it is mainly owing to this that compound fractures are more common in the leg than in any other part of the body. The difference between the two modes of production is essential, and must in all cases be noted. For while the former implies greater or less contusion, almost necessarily followed by inflammation, often by excessive suppuration and sloughing; the latter may be attended by so little injury, as to admit of primary union of the wound, and conversion of the fracture from compound to simple. There are also two ways in which a fracture may become compound at any subsequent period: ulceration of the skin from pressure of a displaced fragment, which most commonly occurs in very oblique fractures of the tibia; and the formation and bursting of an abscess. This accident, the conversion, viz. of a simple into a compound fracture, is most to be feared about the second or third day; but, of course, it may occur latter.

Besides this primary division, fractures may be conveniently classed under four heads: I. Simple, single fractures. II. Multiple fractures. III. Incomplete fractures. And IV. Fractures with complications.

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* For a full discussion of this matter, see Holmes's *Diseases of Children*; also a Memoir read before Med.-Chir. Soc., *Lancet,* April 7, 1860, p. 348.

I. Of simple, single fractures there are two kinds—fracture proper, and separation of epiphyses. Of fracture proper there are also three varieties, named from its direction; transverse, oblique, and irregular or dentated.

Transverse fracture is not met with in the shafts of long bones, though enumerated by most writers. Cruveilhier* considers it impossible. Camper† was not able to meet with a single specimen of the kind in the museums of Germany, England, or Holland. Neither do those of Paris contain one, according to Malgaigne, who also failed in his attempts to produce this kind of fracture in the dead body. Hence it may fairly be concluded that it has never yet been observed. Nevertheless, a fracture may be partly transverse and partly oblique. Transverse fractures occur in irregular and short bones, such as the scapula, lower jaw, patella, and vertebræ; and in the spongy extremities of long bones, as the olecranon and the lower end of the radius; but even in these there is commonly more or less of obliquity.

The great bulk of fractures of the extremities are oblique. The direction of the obliquity may be antero-posterior or transverse, and its degrees are endless; very oblique fractures being often improperly called longitudinal. In dentated fractures the surfaces are studded with irregularities, more or less pointed, and interlocking so as to present obstacles to the displacement of the fragments, or to their reduction when displaced. In such cases the fragments may remain in position, the only perceptible displacement being an alteration in their relative axes, or a bending of the bone. One or more of these points may be broken off, a circumstance which materially affects the nature of the fracture, and the mobility of the fragments. A large proportion of oblique fractures are dentate.

Separation of epiphyses has been so often confounded with simple fracture, or congenital defects, that it is scarcely a matter of surprise that there should still be wide differences of opinion as to its frequency and precise nature. It has been found after death at both ends of the humerus, femur, tibia, and fibula, the lower end of the radius, and upper end of the ulna. It has been diagnosed in other parts, and there seems no reason to doubt that any epiphysis may separate from its bone, the relative facility of the accident at different parts being affected by the mode of growth and connection of the epiphyses.

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* *Traité d'Anat. Path. gén.*, 1849, t. i. p. 86.

† *Obs. circa Callum*, in *Essays and Obs. Phys. and Lit. of Soc. of Ed.*, 1771, vol. iii. p. 537.

This is necessarily an accident of early life, usually before the age of sixteen. In some persons, however, in whom complete ossification is deferred, it may occur at a later period. Some surgeons, notably Mr. Smith of Dublin, believe that commonly the fracture follows the course of the cartilage. The majority of French surgeons, however, who have paid much attention to the subject, think that the separation is generally accompanied by some splintering of the adjoining part of the shaft of the bone, and in this opinion they are strongly supported by the investigations of Mr. Holmes.* As this latter writer observes, the point is of practical importance only as bearing on the prognosis, the liability to subsequent defective growth of the limb being in proportion to the amount of injury to the epiphysial cartilage. The causes and symptoms of the accident are similar to those of ordinary fracture. It may happen during intra-uterine life from blows received by the mother, and has been not unfrequently produced during birth by violent attempts at delivery.

II. Of multiple fractures there are four varieties: 1. Two or more fractures of the same bone. 2. Separate fractures of different bones. 3. Splintered; and 4. Comminuted fractures.

1. Double fractures in the shafts of bones are rare, because they can only be produced, either by the simultaneous action of two separate forces, or (which is virtually the same thing) by the action of a single force over a large surface. For the same reason, they are generally attended with great damage to the soft parts, and proportionate danger. But in the articular extremities of certain bones, as the humerus and femur, they are not unfrequent, owing to the peculiar shape of their condyles, between which any transmitted force is divided. Such fractures of course extend into the neighbouring joint.

2. Fractures of two or more bones are naturally separable into two groups. One of these includes the numerous cases of fracture of contiguous or parallel bones, as the ribs, the two bones of the leg or forearm, the metacarpal or metatarsal bones. The other group comprises fractures of two or more bones in

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* Holmes's *Diseases of Children,* 2nd edit. p. 236.

separate parts of the skeleton. These are comparatively rare, being not more than 1·3 per cent. of all fractures. The leg, the thigh, the arm, and the cranium are the parts most frequently involved. In about one-fifth of the cases there are three separate fractures. More than three are rarely found. The cause of these fractures is almost invariably a fall from a height. As might be expected, they are more fatal than any other class. Produced by great and extensive violence, they are attended with excessive shock, and for the most part with internal injuries. When not so complicated, their danger is in proportion to the number of fractures.

3 and 4. Splintered and comminuted fractures differ from one another principally in degree. A splinter is any pointed fragment, not involving the whole thickness of the bone, except in the case of a flat bone. In comminuted fractures the bone or bones are either separated into innumerable fragments which are isolated and scattered among the surrounding tissues; or they are crushed, and as it were compressed, the bony tissue appearing to occupy less space than originally, as though there were actual loss of substance. This latter form of fracture is seen only in spongy bones, as the vertebræ, os calcis, and articular ends of long bones. A variety of it—impacted fracture—of common occurrence in certain localities, as the neck and lower end of the femur and lower end of the radius, differs from it by its capability of repair without loss of tissue or deformity.

III. There are four species of incomplete fracture: 1. Fissures. 2. Proper incomplete fracture, or bending of bones. 3. Separation of a splinter. 4. Perforations.

1. Fissures are most commonly met with in the cranium. In other flat bones, except the ribs, they are rare. There are records, however, of their occurrence in the lower jaw, and in the os innominatum. In the short bones they are still more rare. They occur, though not often, in the shafts of long bones, commencing at the articular extremity, as between the condyles of the femur or humerus, and being prolonged more or less into the shaft. In the preparation (St. George's Hospital Museum, I. 208) from which the Figs. 8 and 9 are taken, a fissure in the tibia of a child, instead of extending to the joint, begins just below the epiphysis, which is partially separated. The fissure, as may be seen, passes obliquely down the shaft of the bone, extending to its inner surface behind (Fig. 9), though in front it is nearly vertical. As is usual in such fractures, there is a

distinct separation of the lips. Some surgeons have described longitudinal fissures in the tibia and femur which do not at any point reach the margin of the bone. Malgaigne actually depicts such a fissure, professedly from a specimen in the Museum of the Val de Grâce.* But it is difficult to believe in the reality of such fractures, except in the case of radiations from the wounds inflicted by firearms (starred fractures).

Fig. 8.†

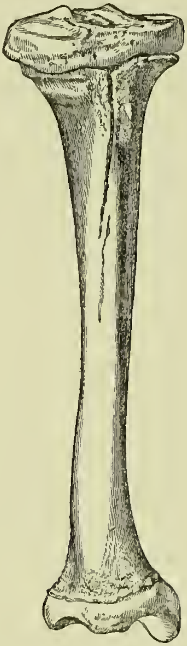
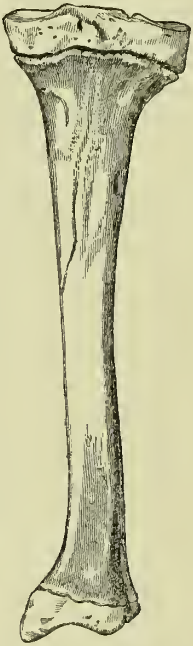


Fig. 9.‡



2. Incomplete fractures, properly so called, occur both in the flat and long bones. Permanent depressions of the cranium produced during birth are usually, and according to some authorities always, accompanied by slight fracture. So, too, in the bones of the adult cranium fracture may be confined to either table, or to the diploë. Partial fracture of the ribs occurs at all ages; and Adams drew attention to its frequency in the neck of the femur.§ The vertebræ bend up to a later

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* *Traité des Fractures et des Luxations*, 1847, plates.

† Fissured fracture of the tibia, front view. St. George's Hospital Museum.

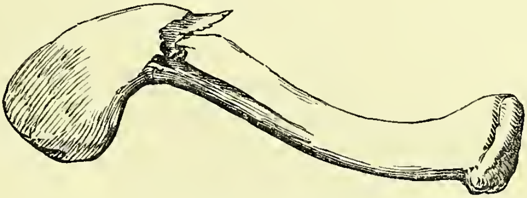
‡ Back view of the same preparation.

§ *Dublin Jour. of Med. and Chem. Science,* vol. vi. 1835, pp. 220 et seq.

period of life than other bones, because they contain more animal matter.*

Bending, or incomplete fracture, or, as known by its best name 'green-stick' fracture, of the shafts of long bones is by no means rare in childhood, especially between the ages of five and fifteen. It has been observed in all the long bones, but most frequently in the forearm. Next in order of frequency come the clavicle, the femur, and tibia. In the bones of the forearm singly, in the humerus and fibula, it is rare. It may be doubted whether simple bending without fracture ever occurs in the human subject; it has only been seen as the result of experiment in the soft bones of very young animals. The usual form of injury is well shown in the accompanying illustration, copied from Holmes's *Diseases of Children* (Fig. 36, p. 234). The fibres on the convexity of the curve have given way, those on the concave side being unbroken. There is no displacement of the fragments, which, indeed, rarely occurs, and the periosteum usually remains untorn. With few exceptions, a bent bone recovers its shape after a few weeks, or perhaps months, by its own elasticity, aided by compression. The possibility of partial fracture in the adult has been called in question by many. Jurine, however, distinctly affirms that he has seen such cases; and that it may be readily produced on adult bones in the dead subject is proved by the experiments of Meding,‡ Campaignac, and Malgaigne.

Fig. 10.†



Bending of Clavicle.

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* *Lettsomian Lect. on the Phys. Const., Diseases, and Fractures of Bones*, by John Bishop, 1855. This author assigns teething, and the quantity of phosphate of lime which that process requires, as one principal cause of the softness of the bones up to the age of four.

† Green-stick Fracture of the Clavicle. St. George's Hospital Museum.

‡ *De Regeneratione Ossium per experimenta illust., Diss. Inaug.* Lips. 1823.

3. The separation of a splinter, leaving the remainder of the bone intact, is a rare accident. It can only be effected by a wounding instrument, as a sabre or ball; hence it is necessarily compound. The cranium and prominent points of bone are most exposed to this peculiar form of injury. Rarely, indeed, are the shafts of long bones so fractured.

4. Perforations, also, are necessarily connected with an external wound. All bones are liable to this form of fracture, which is attended by this peculiarity, that the body which inflicts the injury may remain in the bone, the perforation being complete or incomplete.

IV. The complications of fractures comprise all concomitant injuries to organs other than the bones themselves, and all general affections. Only one distinct variety is included under this head : viz. fractures which extend into a joint. These, unless produced by a ball or penetrating instrument, are usually simple.

Diagnostic symptoms.—The symptoms of fracture are rational and sensual. The rational symptoms are the evidences of injury to internal viscera, resulting from the fracture of the bones which enclose any of the large cavities. As evidences of fracture they are rarely of much value, except in those cases where their gravity indicates that the fracture itself is of secondary importance to the internal complication. The sensual symptoms are of two kinds: certain, pathognomonic, or unequivocal; and uncertain, or equivocal. The unequivocal signs are four: the sharp crack heard by the patient at the moment of fracture, unnatural mobility of the fragments, deformity, and crepitation. The equivocal symptoms are three: pain, swelling, and loss of power.

In the great majority of cases the attention of the patient is distracted by so many circumstances at the moment of fracture, by the sudden pain, by alarm, and by surrounding noise, that he is not conscious of the slight crack produced by the snapping of the bone. It is generally, however, heard unmistakably in cases of fracture, at least of long bones, by muscular contraction; or when the accident happens in a quiet place, as in bed, or during the efforts to reduce a dislocation. It is, when heard, a valuable sign; the only thing with which it would be possible to confound it being the sudden snap of a tendon, or perhaps that of the displacement or rupture of a ligament during dislocation.

Mobility of the fragments is, of course, a necessary condition both of deformity and crepitation. But it is frequently diagnostic without the latter accompaniment, as in fracture of deep-seated bones, or when there is separation of the fragments. The most readily detected and most conclusive test of fracture of the fibula is, mobility of the lower fragment without the upper. It frequently occurs, however, that this symptom is either absent, or not sufficiently decided for the purpose of diagnosis. In many fractures of short and flat bones, as of the spine or pelvis, and in comminuted fractures, it can scarcely be said to exist. The same is the case with some fractures of a single bone, supported by a neighbour, where one acts as a splint to the other; and in dentated and impacted fractures. And in all fractures in the neighbourhood of joints its interpretation is interfered with by two causes—the difficulty of holding the smaller fragment, and the natural mobility of the joint. Lastly, it is a test not to be relied on as applicable to the ribs, on account of their elasticity.

Of all the symptoms of fracture, deformity is the most valuable, because it is the one which gives the greatest amount of information. It is not, of course, present in every case, being often prevented by the shape or connections of the bone broken; as in fracture of the broad upper end of the tibia, or ulna; of one of two parallel bones; of the sternum; of the face, or cranium.

There are five varieties of displacement, having reference, 1. To the diameter of the bone, *transverse* or *lateral*; 2. To its length, *shortening* or *riding*; 3. To its axis, *angular* displacement; 4. To its circumference, *rotation*; and 5. To the contiguity of the fragments, *direct separation.*

Transverse displacement may take place in any direction, though fractures of the same bone preserve, for the most part, a certain degree of uniformity in this respect. Its amount is equally variable. In oblique fractures it is more or less inevitable. When complete, it is necessarily accompanied by shortening, unless this be prevented by the support of a neighbouring bone. In fractures of superficial bones it is readily both seen and felt; and in very oblique fractures, especially of the tibia, the projecting fragment threatens to, and in some instances actually does, pierce the integuments. In more deeply seated fractures it may be ascertained, though not so readily, by tracing the bone with the fingers, and by noting the increase in the diameter of the limb at the seat of fracture.

Longitudinal displacement is present to a greater or less extent in all oblique fractures. In all cases it is the inferior fragment which is displaced. Although, as a rule, it implies the addition of transverse displacement, this is not the case in impacted fractures. In them the lower fragment is generally driven into the upper; but the reverse occasionally happens in the neck of the femur. In most, if not in all of these cases, there is more or less angular displacement, a species of deformity rarely absent from the fractures of long bones, being readily produced by the mere weight of the limb, and which, when distinctly marked, is in itself sufficient evidence of the nature of the injury. Rotatory displacement is also effected by the movement of the lower fragment. It is especially characteristic of fractures of the femur, though not confined to them; and is recognised by comparing the positions of the processes of the broken bone with their natural relations. Displacement by separation takes place in nearly all (transverse) fractures of the patella, olecranon, and os calcis, in all of which it is produced by muscular contraction. It is rarely seen elsewhere; but in some fractures of the lower end of the fibula, the lower fragment may be drawn away from the upper by rotation of the foot; and in severe fractures of the skull there may be an interval between the fragments, or between two bones separated at a suture.

The causes of these various kinds of displacement are four: the continued action of the violence which caused the fracture; the weight of the limb, or of the body; the subsequent action of other external forces; and, lastly and principally, the influence of the muscles. The original violence may produce any of its varieties, with few exceptions. It is the sole cause of impaction, and the chief agent of angular displacement. Most indirect fractures of the lower extremity, and those of the upper which are caused by falls on the hand, suffer from the weight of the body. This, indeed, it is which renders many indirect fractures compound. Angular and rotatory displacement are to a great extent caused by the weight of the limb. It is not often that any subsequent violence is brought to bear on the position of the fragments, except through the imprudence of those who carry the patient, or of himself during delirium. The most powerful and most unfailing cause of displacement is muscular action. This is twofold: healthy, tonic contraction, and spasmodic. The influence of the former is usually heightened by semi-voluntary movements of the patient, provoked by the efforts at reduction. Although muscular contraction has a large share in the production of all the forms of displacement, it is the special agent of shortening. The muscles connected with the lower fragment are answerable for this result, so that in the great majority of cases it is this fragment which suffers displacement, and is to be brought into contact with the upper; the apparent rising of the latter being due solely to the displacement of the former. But in fractures near to the upper end of a bone, transverse displacement may be effected by the muscles attached to the upper fragment, as happens in fracture of the femur immediately below the trochanters, and of the neck of the humerus. In children the fragments usually undergo less displacement than in adults; partly because, on account of the elasticity of their bones, their fractures are more irregular; but principally because the periosteum is often not completely torn across, and the patients are much less exposed to the after-causes of displacement.

In examining for displacement, the only sources of fallacy are the remains of some former injury, which must be learnt by inquiry, and the presence of splinters, or of effused blood; which last may mask, or simulate, a bony ridge. The sensation imparted by coagulated blood has more than once led to error in the examination of the cranium for fracture; and a similar condition is occasionally met with over other superficial bones.

Crepitation may be recognised in most cases of fracture, and is a symptom which cannot mislead. In splintered and comminuted fractures, and when the fragments are loose, the least motion or pressure suffices to determine it. Generally, however, some care and art is requisite for the purpose; the lower fragment being moved while the upper is fixed by a firm grasp, or both fragments being simultaneously moved in opposite directions. In doubtful cases, or where the limb is large, the examination is facilitated by confiding the upper fragment to an assistant, and exploring the supposed seat of fracture with the fingers during the above movements. In certain fractures in the neighbourhood of joints, as the hip or shoulder, rotation of the limb, or flexion and extension, answers the purpose better than lateral movements. If there is any interlocking of the fragments, they must be separated by extension before they can move upon each other. In partial fractures no crepitation can be produced till the bone is straightened, and the broken surfaces brought into contact with each other, and not always then. In many fractures of the ribs, the necessary movements can only be effected by making the patient cough. To facilitate the discovery of crepitation in obscure cases, M. Lisfranc* advocates the use of the stethoscope, which may be occasionally resorted to with advantage in the examination of fractures of the ribs, pelvis, or shoulder, or when there is excessive swelling. But in most cases it is unnecessary and cumbersome.

In many instances this symptom is altogether wanting: in all impacted, and many dentated fractures; when the fragments are separated, as in fracture of the patella; when they ride (in which case it can only be obtained after elongation); also in some fractures of a single bone in limbs provided with two, when its neighbour prevents the necessary movements; or when a clot of blood or bit of muscle intervenes between the fragments.

A sound more or less resembling crepitation may be caused by emphysema; by the rubbing of tendons in their sheaths, or of the inflamed and roughened surfaces of a joint, aided, according to Sir A. Cooper, by the altered state of the synovia. This sound, as compared with crepitation, is slight, dull, and creaking, and may be produced by simple pressure of the joint; and the rubbing of tendons is analogous to it, and jerking. In the discrimination of these sounds the stethoscope has its chief use.

The remaining symptoms, pain, swelling, and loss of power, being common to other forms of injury, are of little or no value for the purpose of diagnosis, except as indicating the precise seat of fracture, or, in some instances, the nature of its cause, whether direct or indirect. However, if no large vessel is torn, the amount of ecchymosis is a good general guide to the extent of the mischief, both to the bone and soft parts. In doubtful fractures, too, pain may acquire importance by its persistence, or even increase, long after the subsidence of ecchymosis and inflammatory swelling, especially if accompanied by acute though circumscribed tenderness.

There are two forms of injury which may be mistaken for fracture—a severe bruise, and dislocation. In some instances of the former it is not possible to obtain conclusive evidence of the nature of the case till after the subsidence of the swelling. There is seldom much difficulty, however, in distinguishing dislocation from a fracture near the joint. In the former the natural movements of the joint are impeded, and the bones are more or less fixed in their new position; they offer considerable resistance to reduction, but, when reduced, remain so. In fracture, besides the crepitus, when it exists, there is preternatural mobility, and the length and shape of the limb may be readily restored by extension, but only so long as this extension lasts. In the fractures near superficial joints, as the elbow or wrist, a careful examination of the relations of the most prominent processes precludes the possibility of error.

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* *Mém. sur de nouvelles Applications du Stéthoscope,* par M. J. Lisfranc. Paris, 1824.

Besides the above general symptoms, variously combined in different cases, there are others peculiar to certain forms of fracture. Of course in compound fractures there is little room for uncertainty, because the nature and extent of the injury is exposed to the view and touch. When a compound fracture extends into a joint, there is commonly an escape of synovial fluid. Care must be taken not to mistake for this the yellow drops of fat which ooze from the subcutaneous tissue, especially in the neighbourhood of the knee: it is recognised by the colour, synovia being white. At a later period these fractures are accompanied by the symptoms of inflammation of the joint itself.

Two only of the varieties of fracture, from certain peculiarities in their history and symptoms, require especial notice—incomplete fractures and fissures. In cases of incomplete fracture in children, the limb is distinctly bent, and offers considerable resistance to reduction. There is little or no absolute shortening; indeed the convex side is lengthened. When the bone is straightened, or nearly so, slight crepitus may sometimes, but not always, be distinguished during rotation. In two or three days, but not before, a slight swelling may appear at the part, and about that time the bone sometimes gives way altogether from subsequent yielding of the periosteum, especially if splints have not been applied from the beginning. The child always evinces pain, and unwillingness to use the limb. The history of violence, generally a fall, and the age of the patient, assist the diagnosis. Occasionally, but not often, a slight transverse fissure can be felt through the skin.

It is very rarely that a simple fissure of a bone can be recognised at first. If it extends into a joint, there may be slight lateral movements of the fragments on one another; and the subsequent inflammation of the joint, especially if severe and obstinate, will justify suspicion.

Treatment.—Immediately after the accident there are certain minor much-neglected precautions to be taken, the observance of which materially affects the comfort and well-being of the patient. Many fractures of the lower extremities are seriously aggravated by his own impatient movements, or by the ignorance and thoughtlessness of attendants. Frequently is a simple converted into a compound fracture, the soft parts are bruised and lacerated, and the foundation laid for violent inflammation and spasms. By small care such accidents may readily be avoided. The patient should be placed on a horizontal support, whether a door or shutter, or a proper litter, and the foot of the injured limb should be tied to the other to prevent its eversion by its own weight. Conveyance in a carriage of any kind is to be condemned. Wherever the nature of an employment engenders many accidents of this kind, special apparatus should be provided. In military practice, litters are indispensable; and M. Vallat contrived an ingenious kind of box to be used in mines, where, from the narrowness of the shaft, it is impossible to preserve the horizontal position. Wathen, too, invented an instrument to fix and extend the fragments during conveyance;* but the utility of such instruments is, of course, limited.

No examination of the fracture should ever be made till the patient occupies that position in which he is intended to remain during the treatment. All voluntary movements on his part must be discouraged during the undressing and subsequent examination. In a very few cases, especially in children, and when there is excessive pain and ecchymosis, it will be found advisable, or even necessary, to place the patient under the influence of chloroform before a proper examination can be made, or reduction effected.

The treatment presents three indications: reduction of the fragments to their normal position; their maintenance in this position till consolidation is effected; and the counteraction of unfavourable constitutional symptoms and complications.

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* *The Conductor*, &c., by J. Wathen, 2nd edit., Lond., 1767.

If there is no displacement, or if, by reason of ecchymosis, or of the depth of the fracture, it cannot be ascertained; or if, although distinctly recognised, it cannot be removed, as in fracture of the spine, any attempt at interference would of course be absurd. The means of reduction necessarily vary with the nature of the displacement. For angular or rotatory displacement, or simple separation, they are sufficiently obvious. But the rectification of shortening by extension presents greater difficulties. It may be made either by the hand or by the assistance of apparatus. French writers speak of the common use of lacs and pulleys for this purpose; but there are serious objections to their employment. The force used in effecting reduction should not greatly, if at all, exceed that which can be permanently maintained: and if the present obstacles to that operation refuse to yield to milder methods, it is better to defer it than to run the risk of aggravating the existing injury by violence.

During extension the upper fragment must be fixed (*counter-extension*) either by the operator himself or by the hands of assistants, care being taken to exert equal force in each direction. For the application of extension, whether during reduction or permanently, Boyer lays down five rules, of which at least four are essential to success: 1. To avoid compressing the muscles which pass over the fracture, such compression being calculated to irritate them, and excite them to increased resistance. This rule is not always regarded, and is the least important; it was, however, one of the objections to some old forms of thigh-splints, that they confined the entire muscles of the limb. 2. To distribute over as large a surface as possible the extending and counter-extending forces. The parts to which these forces are to be applied vary in different cases. The old practice, under Petit's authority, was to grasp the fragments themselves. Boyer, Desault, and others, however, thought that not only would the muscular resistance be diminished, but greater power of extension would be obtained by applying the forces to the contiguous parts of the limb. But, in truth, neither doctrine can be exclusively adhered to. In most cases convenience is the best guide. The grasp must be laid upon that part of the limb which offers the most secure and most effective hold, such as the condyles of the humerus in fracture of that bone, and the foot in fracture of the femur. Except on this principle, no increase of power is, or can be, gained by applying it at a distance from the fractured bone. 3. To make the extension in the direction of the natural axis of the bone. 4. To practise it slowly and gradually, avoiding all jerks and sudden violence, which not only increase the spasmodic resistance of the muscles, but may even lacerate both them and other soft tissues. 5. To protect from undue pressure all parts on which the forces act, and to equalise the compression of the various parts of the apparatus employed.

As soon as sufficient extension has been made, the ends of the bone are to be placed as nearly as possible in their natural relations (*coaptation* or *setting*). This is effected by bringing the lower fragment to the axis of the upper, which remains fixed. In the fractures of subcutaneous bones it is generally easy to see when the extension is sufficient, and coaptation perfect. Not so, however, when the fracture is concealed by extravasation or a thick mass of muscle. Sometimes, indeed, the sudden restoration of the outward form of the limb is a sufficient guarantee of the mutual adaptation of the fragments. Failing this guide, recourse must be had to measurement, the opposite limb being taken as the standard of comparison. Should there be any deformity of the opposite side, resulting from a previous mishap, advantage may be taken of the present accident to equalise the two extremities.

But when extension is complete, it does not always follow that coaptation is easy. The sources of difficulty are three: irregularity of the fracture; the presence of splinters; and the interposition of soft parts. In the case of a dentate or impacted fracture, it is necessary to extend the limb beyond its natural length, and then, by variously-directed manœuvres, to coax the fragments into each other. Partial rotation will sometimes effect the object. But if the displacement resist all reasonable efforts, it is better to suffer the deformity to remain (unless it is excessive, or is likely to interfere with the performance of the functions of the limb), than to run the risk of producing serious mischief by violence. The same may be said of those cases in which reduction is prevented by the peculiar position of a splinter, in which much manipulation would be highly dangerous. Even if the splinter is superficial, unless it is so prominent as to render its ulceration through the skin a matter of certainty, it should be left alone. Only in the latter case is it justifiable to extract it. When any soft parts intervene between the fragments, they are generally released by the means indicated above. If they are not, M. Laugier has proposed to divide them by subcutaneous incision.* In the one case of fractured femur, however, in which he tried it, he not only failed to effect reduction, but he created an abscess, which occasioned the death of the patient. It is far better to trust to the probability of the absorption of the intervening tissue by the pressure of the fragments.

As a general rule, reduction is to be effected immediately after the accident. Some surgeons, it is true, recommend that it be delayed for three or four, or even ten or twelve days,† till all fear of inflammation be past. No reparative process being yet commenced, the position during that period does not affect the final result; and the difficulties of reduction are, according to them, scarcely, if at all, increased by the delay. Nevertheless, immediate reduction has great advantages. It restores the patient to comparative comfort, and diminishes the chances of spasms and other evils resulting from the mal-position of the parts. Moreover, it is not true that reduction at a later period is equally easy. Not only are the fragments more or less fixed by surrounding effusion, but the muscles, accustomed to a new position, offer greater resistance to a change. There are, however, two classes of cases in which immediate reduction is either impracticable or inadvisable. If there has been from the first excessive ecchymosis, or if when the patient is first seen much inflammation has already supervened, the attempt may be not only unbearable, but highly injurious, causing laceration of the soft parts, spasms, convulsions, or even tetanus. The inflammation must be combated by the ordinary means, and reduction deferred till it is fully subdued. Still more serious is the obstacle presented, in the other class of cases, by excessive spasm. Spasm is a very constant accompaniment of fracture, especially if in the neighbourhood of a joint; so constant, indeed, as to be considered, in doubtful cases, almost diagnostic. Its degrees are variable, from slight nocturnal twitchings, ceasing after the second or third day, to uncontrollable oft-recurring contractions, accompanied, it may be, by general convulsions. The severer form of continued spasm is far less frequent than the intermittent. The causes of spasm are three: the irritation of the fragments, injury to nerves, and the altered position of the muscles themselves, whether increasing or diminishing their habitual tension. If they are much bruised, the spasm may be less severe at first than at a later period, after they have recovered their functions. The defeat of spasm by violence is hopeless. Laceration of the muscles, or even of the vessels, will be the only result. Boyer induced fatal hæmorrhage by violent and abortive efforts to reduce a fracture of the femur.* In other cases such efforts have led to convulsions or tetanus.† Still more hopeless will be the attempt if inflammation is superadded. The two main remedies to be relied on are position and energetic antiphlogistic treatment. For pure and simple spasm full doses of opium are of great service; but if it is combined with inflammation, they only tend to mask without abating the evil. The same may be said of the inhalation of chloroform, but it is necessary to give it repeatedly in small quantities, so as to sustain its narcotising influence; for, in severe cases, the spasms will return, whenever its effects pass off, for many days. The limb should be placed in the position of semiflexion, relaxing the muscles to the utmost. But when all these means fail, recourse may be had to subcutaneous division of the opposing muscles, an operation which has hitherto been practised only in the lower extremity. (See INJURIES OF THE LOWER EXTREMITY.)

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* *Bull. Chirurg.*, part ii. p. 253.

† Sir S. Hammick recommends a fractured femur to be left till the tenth or twelfth day.

In the reduction of incomplete fractures considerable difficulty may be experienced. Immediate complete reduction is, indeed, out of the question. Usually, however, the curve yields partially, to be entirely removed only after many days, or weeks, by the pressure of splints. But if from irregularities of the broken surfaces even this partial yielding cannot be obtained, and the mal-position interferes materially with the functions of the limb (such as pronation and supination in curvature of the fore-arm), the fracture must be rendered complete in order that it may be reduced.

After reduction is effected, the whole treatment is directed towards obviating the influence of those causes which tend to reproduce displacement. Those causes are three: 1. The weight of body, the limb, and its coverings. 2. The action of the muscles. 3. The movements of the patient. They are to be obviated by position and apparatus. But whatever be the position adopted or the apparatus employed, it is essential that the basis of support for both the body and limb be firm, unyielding, and equable. Accordingly, for fractures of the lower extremity, soft beds are inadmissible. The best is a horsehair mattress, resting on a wooden frame, or on a board extending from the hips downwards. It is also essential, whatever kind of apparatus be used, that every part of the limb be equally supported, otherwise its own weight will reproduce displacement. The apparatus must be adapted, by its own shape, or by the use of pads, to the inequalities of the limb. All pressure on prominent points must be avoided.

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* *Gaz. des Hôpitaux*, 1844, p. 535.

† Malgaigne, op. cit. pp. 198, 284.

Formerly it was the custom to apply some kind of cerate immediately to the fractured limb. It was supposed to increase the support afforded by the bandages and splints; to repel inflammation; and, as a local sedative, to diminish pain. The practice, however, has been long discontinued. Not only was it altogether useless, but the fat checked and retained the natural secretion of the skin, and becoming rancid, was a frequent cause of pruritus and eruptions.

The apparatus for retention is very various. It includes, 1. bandages; 2. splints; 3. junks; 4. numerous forms of hyponarthecic apparatus; 5. apparatus for maintaining the flexed position; 6. suspensory apparatus; 7. special means of maintaining permanent extension; 8. immovable apparatus.*

In fracture of the extremities, various advantages have been assigned to the use of circular bandages beneath the splints, i.e. immediately to the limb. They have been supposed to contribute to the support of the fragments; to diminish œdema, and promote absorption of effusions; and to abate the irritability of the muscles by the equable compression of all parts of the limb. For support, however, they are altogether superfluous; their influence on spasms is questionable; their pressure is often unbearable and injurious, and they remove from view the seat of fracture. They are of service only if the splints occasion œdema (which, however, if properly applied, they rarely do). If they are used, it is necessary to examine the limb frequently, lest hidden mischief supervene. The early application of circular compression has, on several occasions, given rise to fatal gangrene, which has not been manifested by pain or any other symptom till too late. The many-tailed bandage, or the bandage of Scultetus, may sometimes be useful in inflamed and compound fractures for the retention of dressings, the absorption of discharge, and the approximation of the sides of the wound.

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* For the description and use of the various apparatus, see the articles on the special fractures.

Most fractures may be conveniently treated with splints. Pasteboard splints, which admit of being accurately moulded to the limb, may be used for nearly all fractures in children, and for those of the phalanges in adults. In other cases the support they give is insufficient. Metal splints are for the most part cumbersome. The length of splints must vary according to the purpose which they are intended to answer, and the limb to which they are to be applied. Their proper use is to preserve steadiness of the fragments without compressing the actual seat of fracture. Pott accordingly lays down a rule that they are to include the joints above and below. In fractures of the leg this is to be universally observed, because all kinds of displacement are thus obviated. But the rule is not absolute. In fracture of the femur, the prominence of its condyles, and the thickness of soft parts, would annul the efficacy of splints so placed. The same is the case with the humerus; and in fractures of the upper extremity generally, flexion of the joints is a positive bar to the application of the law. But splints confined to the length of the shaft of the bone have less power over angular displacement, and little or none over rotation. Whenever the movements of a joint would derange the fragments, that joint must be confined by the splints. This is especially the case with fractures of the phalanges, and those in the neighbourhood of the joints.

A good occasional substitute for splints is found in junks, which, enclosing three sides of the limb, on all of which they make equable compression, sometimes succeed in overcoming displacement, even obstinate riding, where splints fail.

At sundry times various kinds of circular splints have been invented, so made as to surround not only the fractured limb, but the adjoining part of the trunk. But as they are costly and inconvenient, and answer no purpose which cannot with some pains be attained by more simple means, they have rapidly fallen into disuse.*

By hyponarthecic apparatus is meant that which merely supports the limb beneath, leaving it free and exposed to view elsewhere. The indications aimed at in its employment are two: position (many of its forms having special arrangements for flexion), and exposure of the limb for examination and the application of dressings. For the latter object they are indispensable in the treatment of inflamed and compound fractures, being the only forms of apparatus which can rconcile the proper care of the wound with firm retention of the fragments. In other cases their utility varies according to the kind of fracture to be treated. It is manifest that, unless combined with splints, they are capable of opposing but a slight obstacle to lateral or angular displacement. But, on the other hand, it is easier to maintain extension with them, and they are recommended by simplicity and facility of application.

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* For an account of such machines, see Wiseman's and Heister's works. Also Lafaye, in *Mém. de l'Acad. de Chir.* t. ii. p. 403; and Bonnet, *Mém. sur les Frac. du Fémur,* &c. in *Gaz. Méd.,* 1839.

The great mass of apparatus recommended by different authors bespeaks alike the great facility with which some fractures are treated, and the insuperable difficulties presented by others. In these latter a selection can only be made by strict attention to the indications to be answered. These are commonly but two: fixation of the fragments, and their maintenance in apposition by opposing the particular kinds of displacement present. In some cases there is a third: exposure of a certain part of the limb, for the treatment of local complications. The greatest difficulties are created by shortening, and numerous methods of maintaining permanent extension have been devised. The most simple and most common is direct traction, as provided for in Desault's thigh-splint, and in many forms of hyponarthecic apparatus. The use of a weight and pulley for this purpose, formerly in vogue, has been of late reintroduced at University College Hospital and elsewhere. A second mode of extension is the conversion of a contiguous bone into a lever, as the humerus in the treatment of fractured clavicle, or the femur in fractures of the leg. And, inasmuch as shortening cannot occur, except in impacted fractures, without producing some degree of lateral displacement, so the lateral pressure of splints or junks, by the obstacle which it presents to the one, is often sufficient to counteract the other. This is the feeblest mode of producing extension; nevertheless, in most fractures of the upper extremity, and many of the leg, no other is required. Only care must be taken that the lateral pressure be not carried to an injurious extent. In all cases of very oblique fracture, where the fragments readily glide upon one another, union will be greatly accelerated by firm lateral pressure either by splints, pads, cravats, junks, or by Amesbury's apparatus. There are cases, however, in which great obliquity, and frequent spasms, aided perhaps by great muscular power and irritability of the patient, or by tenderness of the skin, precluding the employment of much pressure, or necessitating frequent change of apparatus, will render all these means nugatory.

In compound fractures the difficulty of retaining the fragments has been occasionally met by ligature or suture of the bones. Ligature by brass, silver, or lead wire has been very rarely adopted.* Suture is more feasible and more efficacious; but not often necessary, nor altogether free from danger.†

It is seldom possible to obtain absolute immobility of the fragments. Neither is it essential, though M. Bonnet in France, and Amesbury in this country, have insisted on its necessity, and the insufficiency of ordinary apparatus (vide infra, p. 84). It is usually enough to warn the patient to restrain his own movements during the first few days. Only in the cases of children, of restless, delirious, and maniacal patients, are greater precautions necessary. In children immovable apparatus may safely be used at an earlier period than in adults; but, on account of the delicacy of their skin, greater care is necessary to avoid tight pressure. In consequence of their habits, the apparatus must be protected from urine, &c. In cases of delirium it is sometimes absolutely essential forcibly to restrain the patient by strapping him, as well as the injured limb, to the bed. In such cases some form of immovable apparatus should be applied as early as possible.

In all cases the fracture must be examined from time to time—to see that coaptation is not disturbed, necessitating readjustment. This can usually be done without deranging the apparatus. But, whenever any kind of circular apparatus is employed, it must be removed for the purpose after all swelling has subsided, and before union has too far advanced; viz. after the lapse of from one-half to two-thirds of the time requisite for consolidation.

When the period ordinarily required for union has elapsed, a careful examination of the limb must be made before it is allowed to resume its functions. Sometimes, even when examination by the hands gives an impression of firmness, yet the incompleteness of union will be manifested by the supervention of pain during use of the limb, in which case the treatment must be resumed. After the union of a simple fracture, there is rarely much impediment to immediate freedom as soon as the apparatus is removed. Even in fractures of the lower extremity, the liberty enjoyed by the patient during the latter part of the treatment gives him confidence and earlier use of the limb, besides diminishing the risk of œdema. But the restoration of the functions may be impeded by two causes: atrophy of the limb, and stiffness of the joints.

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* Icarte, 'Lettre en réponse à M. Pujol,' in *Jour. de Méd.*, 1775, p. 164.

† Laloy, 'De la Suture des Os,' &c., *Thèse inaug.*, Paris, 1839.

Atrophy is generally the consequence of prolonged suppuration; but occasionally it proceeds from the excessive pressure of apparatus in the early treatment. It gradually yields to tonics, position, and gentle exercise of the atrophied muscles.

Stiffness of the joints arises from two causes: inflammation, when the fracture has been in their neighbourhood, and long-continued immobility. Even when the joint is in no degree implicated in the fracture, long confinement in one position, especially extension, induces partial immobility of the joint. This effect is due mainly to a tonic contraction of the ligaments, and, in a minor degree, of the tendons. The muscles also become more or less retracted, and lose both volume and power; but their influence in fixing the joint is much less than that of the ligaments. It also appears, from certain observations of M. Tessier,* that long-continued fixed extension of a joint is capable of setting up in it (by the mutual pressure of the articular surfaces) a real inflammation, with its consequences, viz. formation of false membrane, destruction of the cartilage, and partial anchylosis. There is but one mode of avoiding this disastrous result in all cases in which it is threatened; viz. gentle exercise of the joint from the earliest possible period, that is, from the earliest period at which such exercise will not interfere with the union of the fracture. The observance of this rule is of especial importance in fracture of the upper extremity; the effects of anchylosis being there most disastrous. The treatment may be assisted by frictions, emollients, and douche baths; but these are to be regarded as secondary to constant exercise.

At any period, till the new bone has acquired perfect solidity, it is liable to bend or break from the weight of the body, from blows or falls. This accident is not rare. Accidental bending of the femur has been seen so late as the 135th day,* and refracture eight or eighteen months, and even two or three, and in one case seven years after the first;† but in these extreme cases union has been delayed, or, from deformity, has never been strong. These secondary fractures unite more readily than the first, from the spongy nature of the new bone; and curvature readily yields to pressure.

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* *Gaz. médicale,* 1841, pp. 609, 625.

Treatment of compound fracture.—Although the rules of treatment laid down for simple fracture are equally applicable to compound, yet the latter present certain special points for consideration, viz. the reduction of a protruding fragment; the treatment of splinters and loose pieces of bone; and the mode of dressing the wound.

It is usually the upper fragment which protrudes. When the wound in the skin has been made by the pressure of the fragment itself, it is commonly small, and occasionally girts the bone tightly. The difficulty of reduction is in proportion to the size of the wound, the length of the protruding bone, and the degree of accompanying spasm. If reduction cannot be effected by moderate extension and dexterous manœuvring, the wound must be enlarged. But although this measure is attended with far less danger than violent efforts of extension, it is yet to be adopted as sparingly as possible. The enlargement is to be made in that direction in which the smallest additional division will give the greatest amount of freedom. This will usually be in the axis of the bone. If, on account of the length or sharpness of the protruding piece, even this is not sufficient, the end of the bone, so far as necessary, must be sawn off. In compound, as in simple fractures, excessive spasm may render it necessary to postpone complete reduction, but under no circumstances may the bone be allowed to remain protruding.

If the bone is splintered or comminuted, some judgment is required in determining what pieces to remove and what to leave. Splinters are of three kinds. Some, though split away from the bone, are still connected to it in their whole length by the periosteum, to which they are firmly adherent. These, in young and healthy subjects, are not to be touched; they become reunited to the bone; they rarely die. But in the old, and in cases of gunshot wound, it is prudent to remove them. Others are completely torn away from the bone, and are found lying loose among the surrounding tissues. All these are to be carefully removed, whether they carry with them their periosteum or not. If, being at a distance from the fracture, they are not easily reached through the wound, a counter-opening may be made for the purpose. A third set are partly adherent, partly not. These may reunite: more commonly they partially die, in proportion to the injury to their periosteum, and keep up for a long period—for months, perhaps for years—a succession of abscesses, retarding, or entirely preventing, union, greatly prolonging the danger, and involving, it may be, the ultimate loss of the limb. They must, therefore, so far as is practicable, be removed. But some allowance may be made for differences in their position. If they are at the bottom of a deep wound, and difficult to reach, it is the better and less hazardous course to make no attempt at interference. Such attempts have resulted in gangrene and death.* On the other hand, should the fracture be in the neighbourhood of a joint or of a visceral cavity, on no account may they be suffered to remain. They are even more injurious there than elsewhere. In the treatment of these fractures the most perfect clearance of all loose fragments is the first requisite. The bones of the face, however, except the lower jaw, are so well supplied with vessels, and their repair is so energetic, that much more latitude is allowable in dealing with splinters in their fractures than in others, especially as it is more than usually desirable to avoid deformity in that region. All sharp projections of the splinters which are left, or of the fragments themselves, should be nipped off; they may wound or lacerate the soft parts, or open some vessel. For the purpose of removal (which should be done by the fingers in preference to instruments), it may be necessary to enlarge the wound. In all cases, all tendinous or membranous structures which obstruct the removal, or unduly confine or strangulate the soft parts during the subsequent inflammation, are to be freely divided.

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* Guillon, *Thèse inaug.*, Paris, 1820.

† Œsterlen, op. cit. obs. 21–30; and Malgaigne, op. cit. p. 326.

If there is hæmorrhage, it is to be treated on the same principles as in other wounds, the employment of pressure being, however, somewhat limited by the state of the bone. All projecting threads of lacerated muscle or tendon should be cut away. Then the wound is to be dressed; and it is, perhaps, in cases of this class that the antiseptic treatment introduced by Mr. Lister has achieved some of its greatest triumphs. It must always be remembered that the primary object is the conversion of the fracture, if possible, from compound to simple. This is of so great importance, that it should invariably be attempted. If the attempt is only partly successful, some advantage is gained. The end may be attained in simple cases by the old methods of dressing with some unirritating plaster, or lint dipped in blood. Some surgeons prefer the use of Dr. Richardson's 'styptic colloid.' But there can be little question of the great superiority over all these means of Lister's treatment, under which, when applied with the necessary care and precautions, many very severe and dangerous fractures have been speedily brought to a condition of comparative harmlessness.

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* See a case related by Bessière, in which an attempt was made to remove a ball and splinter from between the radius and ulna, 'Des Complic. des Fractures,' *Thèse inaug.*, 1851.

There are but two classes of cases in which sutures are admissible: firstly, when an endeavour is made to save a limb, as a finger or hand, which is nearly divided across; and, secondly, when the skin is peeled off from the underlying tissue. In all other cases they must be regarded as useless irritants.

As soon as it is clear that the effort at primary union has failed, the first dressings are to be removed, and the wound to be treated according to its condition, as though it were uncomplicated with fracture. For the fracture only modifies its condition by permitting motion, and the consequent interference with the natural process of union. Nevertheless, this interference is so great as to occasion, in many instances, the severest form of suppuration.

Whatever form of retention be used, all circular apparatus is, in the opinion of the author, to be rejected. Immovable apparatus covering the wound was employed by Larrey, and is still, from time to time, strongly advocated by some surgeons. But whether admissible or not in the first stages of the treatment of simple fracture, it undoubtedly has great disadvantages in compound cases. The discharges accumulate beneath it, soaking the dressings, diffusing themselves over the limbs, and in some instances burrowing largely among the muscles. Such an apparatus would of course be incompatible with the success of the antiseptic treatment recommended above.

Complications.—A fracture in a healthy subject, whether simple or compound, unaccompanied by inflammation or fever, demands little or no constitutional treatment. Even the slight antiphlogistic regimen usually enforced after an accident should be modified, in consideration of the great labour of repair which is to follow. In fractures of the lower extremities aperients must be avoided, on account of the movements which they necessitate.

Complications are either local or general. The former include affections of the skin—pruritus, vesications, excoriations, wounds, and erysipelas; of the vessels—ecchymosis and hæmorrhage; of the areolar tissue—inflammation, suppuration, and gangrene; of the bone—inflammation, caries, and necrosis; of the muscular and nervous tissues—spasms, convulsions, paralysis, and neuralgia; and, lastly, of neighbouring organs, the joints or viscera.

These complications may be produced simultaneously with the fracture, or may arise at a later period. Of course, for many the treatment is not influenced by the coexistence of the fracture. Pruritus is almost always the result of improper dressings. If the skin is much distended, especially when the fracture is superficial, as in the leg, there commonly arise, in a few hours, several vesications filled with a light-coloured viscid fluid. If let alone they either burst or shrink from absorption of their contents. Much relief to the sensation of tension is afforded by pricking them, without removing the cuticle. They must not be confounded with the vesications of erysipelas, which are numerous and clustered, small, tense, and surrounded by the peculiar blush of that disease; nor with those which precede mortification, whose contents are dark and tawny.

Fracture of the bones enclosing a visceral cavity is not necessarily accompanied by any injury to the viscera themselves. When it is, the latter is to be treated as the primary injury, influenced by the fracture in two ways: by the movements of the fragments, or by the pressure or irritation of displaced bone, or of a splinter.

The same considerations apply to fracture extending into a joint. As this accident must, in most instances, lead to anchylosis, the joint should be placed, from an early period, in the best permanent position.

When a fracture is accompanied by dislocation, the attempt to reduce the latter must be made at the outset. The possibility of its reduction depends partly upon the kind of joint affected, and the nature of the dislocation, but principally upon the situation of the fracture. Dislocation of a ginglymoid joint may generally be reduced, especially if its ligaments are weakened by laceration. But if it be an orbicular joint, deeply buried among powerful muscles, and the fracture be below it and in its immediate neighbourhood, reduction is not possible. Neither will it be possible after union of the fracture; at least, there is no instance of it on record. Nevertheless it will, of course, be right to attempt it; with which view the muscles and ligaments of the joint should be, as much as possible, relaxed by habitual movements from an early period of the treatment. Boyer also recommends for this purpose the use of emollients.

The general complications are such as are common to all injuries, viz. inflammatory fever, hectic, delirium tremens, purulent infection, phlebitis, tetanus, and retention of urine.

In a certain proportion of cases, one or more of the above complications will necessitate either primary or secondary amputation. There are but two conditions which demand immediate amputation: profuse hæmorrhage, and extensive injury to the soft parts, threatening excessive inflammation or mortification. But the cases presenting one or other of these conditions are various:

1. When a limb is shot off by a cannon-ball or a portion of a shell.

2. When the division of the soft parts is nearly complete; except in the case of a clean cut across the phalanges, metacarpus, or metatarsus. Even the forearm may occasionally be saved under similar circumstances.

3. When there is much actual loss of soft parts, as when one side of a limb is torn away or the skin is extensively peeled off.

4. When, in addition to great comminution of the bone, there is so much bruising and laceration, with deep separation, of the soft parts, especially of tendons, that gangrene appears inevitable. These cases, however, except as the result of gunshot wounds, are very rare. In healthy subjects, the tissues, unless absolutely destroyed, will for the most part recover. In

a few cases, specially noticed by Velpeau* and Malgaigne,† the parts in the neighbourhood of the fracture are within a few hours attacked by spontaneous emphysema, without any communication with the lungs. It appears to be simply an early symptom of gangrene from the sudden death of the part, and demands immediate amputation.

5. When a fracture, effected by some large body, as a waggon-wheel, is accompanied by laceration of the muscles and destruction of important nerves, but not of arteries.

6. When the principal artery and nerve of the limb are both divided.

7. Some cases of hæmorrhage. A wounded artery alone is not sufficient to justify the operation. But if it be accompanied by much laceration of the other tissues, the issue will depend very much on the position of the artery. If it be the brachial, the limb may generally be saved; if the femoral, it must be sacrificed. A wound of the posterior tibial, where it is deeply covered by muscles, or of the interossei in the arm, may resist all other treatment. Amputation will occasionally be rendered necessary by general hæmorrhage from a number of small branches, especially when it is persistently induced by warmth. There are, indeed, cases on record where it has been required in simple fracture of the tibia, in consequence of continued oozing from the divided medullary artery. There is a peculiar form of injury mentioned by military surgeons, ascribed by some to the wind of a cannon-ball, but by Larrey, with more probability, to a spent ball, in which, without any division of the skin, bone, muscles, and tendons are crushed, and the artery lacerated. Before amputation, the skin should be divided and the parts examined, as it may be that the muscles are the only soft parts injured, in which case the limb may be saved.

8. Several forms of compound fracture of large joints, viz. when either bone of the joint is shattered, or both are broken; when there is much destruction or laceration of the ligaments; when, in addition to comminution of the bone, there is much contusion of the soft parts, especially if complicated with division of an artery; when the articular surfaces both of the bones and ligaments have suffered much damage,

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* *Médecine Opératoire,* 2nd ed. t. ii. p. 321.

† *Traité des Fractures,* &c., 1847, p. 351.

accompanied by effusion into the joint; when there is displacement of the fragments within the joint, and they present rough edges, as in the case of separation of the condyles of the femur, transversely from the shaft or perpendicularly from each other, in consequence of the passage of a ball; when the foreign body which has caused the fracture remains in the joint, or projects into it from its bed in the bone, and cannot easily be removed, or when, in its passage through the joint, it has inflicted great injury on the articular surfaces; and, lastly, in the case of an extensive incised wound into a large ginglymoid joint, with internal effusion of blood. It is to be understood that all these forms of injury are most fatal when affecting the knee: in dealing with other joints much greater latitude may be allowed. Moreover, whenever the injury is confined to the joint, with little or no damage to the neighbouring soft parts, excision may be substituted for amputation.

But although it is true that under most of the above conditions salvation of the injured limb is well nigh hopeless, and the attempt would jeopardise the life of the patient, yet it must be admitted that the discrimination of the cases in which that attempt may reasonably be made is frequently a matter of difficulty, and has created much discussion. For, besides the extent, kind, and position of the injury, the age, constitution, and habits of the patient materially influence the result. Many limbs may be preserved in the young and healthy which must otherwise have been sacrificed. Moreover, with them greater risks may be incurred, as they are better able to encounter the dangers of secondary amputation, if it become necessary. The introduction of Lister's treatment, too, will justify the attempt to save many a limb that must formerly have been condemned.

If, in addition to the fracture, there are serious injuries to other organs, immediate amputation is either useless or injurious. In such a case the only chance of recovery is afforded by secondary amputation after the early dangers are past.

Secondary amputation may, of course, be required for profuse suppuration with hectic, for gangrene, or uncontrollable hæmorrhage. These, being common to other forms of injury, demand no special notice.

At a still later period, after all danger has ceased, the operation may be desired by the patient, if, in consequence of non-union, incurable deformity, or tedious disease of the bone, the limb has become an encumbrance to him. Similar symptoms may occasionally be treated by excision.*

Process of union.—Notwithstanding the labour which has been bestowed upon the study of the healing process in bone, the greatest misconception of its nature has, till within the last few years, prevailed, and many of its details remain yet to be determined. This is due to many causes: the nature of the tissue; the scarcity of opportunities for examination of the various stages of the process in man; its essential difference in animals, on which alone experiments could be made; and, lastly, actual differences in different fractures, according to their varying conditions.

The injury is seldom limited to the bone, but is accompanied by more or less bruising and laceration of the neighbouring soft tissues and surrounding extravasation of blood. This extravasation varies greatly in quantity, and is unequal in its distribution. If no considerable vessel is torn, it is in proportion to the displacement and sharpness of the fragments, and the extent of injury to the periosteum. It is most abundant in the subcutaneous cellular tissue. Here, too, its absorption is least rapid; Paget having found it, in one case, nearly unchanged after a period of five weeks. In the periosteum and medullary membrane there is usually little or none. The periosteum is rarely much damaged in simple fracture. It is not often stripped off, but is generally simply torn across, and slightly frayed at the edges, but retaining firm union to the bone up to the level of the fracture. In partial fractures it is frequently uninjured. It may even remain entire in complete fractures, especially in children, in which case it subsequently thickens, contributing to the facility and security of the repair.

During the first two or three days there is a slight inflammatory exudation amongst the soft tissues. Only in the severer cases does this amount to distinct swelling, perceptible for many days, and accompanied by general fever. It is succeeded, according to Paget, by a period of rest, of incubation, lasting for a week or ten days, or even more, during which absorption of the blood and effused fibrine proceeds; but the proper reparative process is suspended. Meanwhile the deep-seated muscles, in all cases more or less lacerated, are found adhering together and to the neighbouring soft tissues and periosteum, their torn ends rounded off and lost in the fibrinous effusion. About the sixth day their repair has commenced, and is completed by cellular tissue some time before the union of the bone is effected. About the end of the first month they have lost all adhesion to the periosteum.

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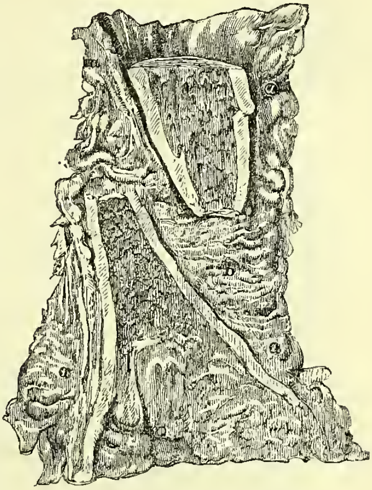
* Excision of the knee has been performed for mal-union of the patella. *Med.-Chir. Trans.* vol. xli. p. 195.

The proper reparative process of the bone is precisely analogous to that of soft tissues. It is divisible into two parts, as distinct in their objects as in the time which they occupy, the former being completed, or nearly so, before the second begins; viz. the actual process of union, and the subsequent shaping of the fragments and of the uniting substance.

In a few cases, immediate union occurs without the intervention of any new material. According to Paget, this is very rare: but Hamilton considers it to be a frequent, if indeed it be not the normal mode of union in spongy bones, and the spongy extremities of long bones, especially after impacted fractures, as seen in the neck of the humerus and femur.

In the great majority of cases, however, a proper reparative material is provided, precisely similar in its early growth to that employed for the repair of soft tissues by adhesion. This material is of course supplied mainly by the vessels of the bone itself and of the periosteum; in a minor degree by those of the medullary membrane; and secondarily, through the intervention of the above, by the vessels of the surrounding tissues. The period of its first effusion in man cannot, as yet, be accurately stated; probably it is between the tenth and twentieth days in fractures of the large, but earlier in those of the small, bones. If the injury to the neighbouring tissues be but slight, and the fragments have been, from the first, kept at rest and in strict apposition, this material is found chiefly, or it may be solely, between them. When it extends beyond them, it occupies, indifferently, the tissue of the periosteum, the space external to it, or between it and the bone; variations in this respect depending probably on the degree and nature of the injury to the periosteum itself. In fig. 11, representing the section of a femur fractured above the condyles six weeks before, the connecting tissue, distinguished by a well-marked transverse striation (b), is shown lying between the fragments, and also between them and the periosteum, which in this, as in many instances, is much thickened (a a). In a recent specimen the reparative material may also be traced slightly into the medullary tissue, but not between it and the bone. The extent of its external diffusion may vary on different aspects of the bone. In fractures of superficial bones, as of the tibia, it not unfrequently happens that the deep surface is rough with deposits, from which the superficial is perfectly free.

FIG. 11.*



The transitional forms through which this material passes in its development into bone are not in all cases the same. In a few, ossification is preceded by the production of perfect fibrous tissue. This is the case in the union of fracture of the cranium, and, perhaps, of other flat bones; in some slowly-uniting fractures of long bones; and in the closing of the exposed end of the medullary canal, when the fragments overlap. More frequently, however, the deposit of earthy matter proceeds simultaneously with the development of the fibrous matrix, so that the rudimental nucleated blastema appears to be at once developed into bone. This is stated to be the normal form of ossification in the repair of quickly-uniting fractures. Lastly, in some cases, especially in young subjects, the development is through fibro-cartilage. In animals, genuine cartilage is commonly, perhaps always, produced. Hence it has been conjectured that it may be found, occasionally at least, in children. But although the general appearance of the new tissue has been adduced in support of this conjecture, it has not as yet been proved that it is ever more in the human subject than fibro-cartilage.

Whichever of the above modes be followed, ossification may commence either at the surface of the old bone, or in several separate centres. The corpuscles, at first round, rapidly shoot out and acquire their peculiar characters. Then the Haversian

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[*] Fracture of the femur, to show the conditions of union six weeks after the accident. From the Museum of the Royal College of Surgeons, No. 415.

canals are formed, and subsequently canals for blood-vessels. For some time the new bone is porous and spongy, like fœtal bone; its change into compact bone is very gradual.

When the fragments do not actually correspond, the uniting medium occupies externally the angle between them, and extends partly into and across the medullary canal. When they completely overlap, and even when there is an interval between them, provided it be not too great, the same rule prevails. The reparative material simply lies between them, bridging over the interval, and filling up all angles and irregularities. It does not

Fig. 12.*

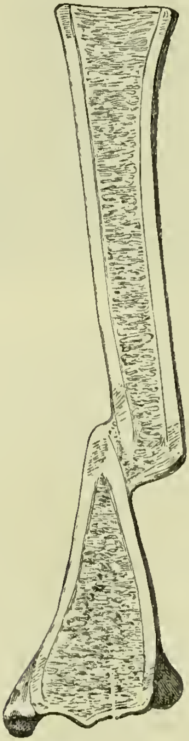
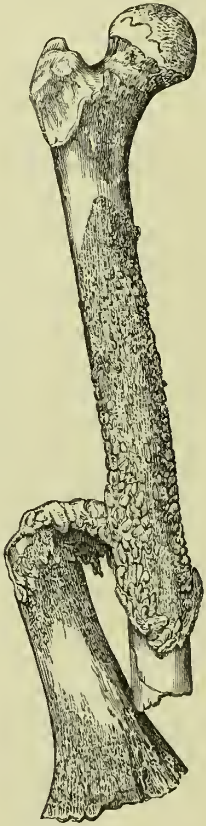


Fig. 13.†



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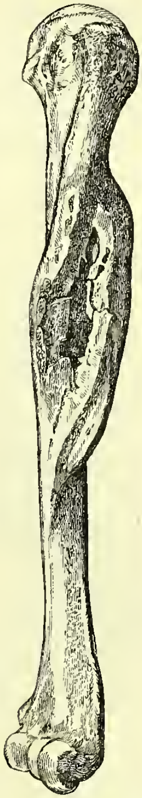
* United fracture of tibia. From the Museum of the Royal College of Surgeons. To show the fragments merely glued together by reparative material thrown out between them.

† Union of displaced fracture by a bridge of bone. From a preparation in the Museum of the Royal College of Surgeons.

occupy any part of the medullary canal: it does not even cover the exposed ends of the bone. This simple *glueing* together, as it were, of the adjoining surfaces, without any redundant matter, is well shown in Fig. 12, of a tibia, sixteen weeks after fracture. (Mus. Coll. Surg. No. 438.)

When, in addition to overlapping, the fragments are more or less widely separated, bridges of new bone, greatly varying in extent and connections according to the requirements of different cases, form the bonds of union. In the femur here represented (Fig. 13, from Mus. Coll. Surg. No. 458), where there is great divergence of the fragments, such a bridge unites the end of the lower fragment to the side of the upper. The quantity of rough deposit on the shaft of this bone is a measure of the disturbance to which it was subjected during union. In the humerus depicted in Fig. 14 (Mus. Coll. Surg. No. 2938), a strong bridge of union has been formed by the attachment of the two extremities of a large separated splinter to the respective fragments.

FIG. 14.*



Under certain circumstances this process undergoes a modification so marked, that its essential identity with the process of union in other tissues was long overlooked. Of universal occurrence in animals, and therefore observed in all experiments, this modification was first fully described by Dupuytren, on whose authority mainly it was accepted, till within a few years, as the sole and normal mode of union of simple fractures. It consists in the production, at an early period, of a ring or 'ferule' of bone around the fragments, called by Dupuytren 'provisional callus,' and constituting a kind of natural splint, beneath which the permanent union by intermediate or 'definitive' callus takes place much later. The whole process was conveniently, though artificially, divided by Dupuytren into five periods.

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* Union of fracture by the attachment to each fragment of a bridge formed by a separated splinter. From a preparation in the Museum of the Royal College of Surgeons.

In the first, comprising in animals eight or ten days, the peculiarity of the process is already seen in the more copious exudation of the reparative material, both externally to the fragments, between them and the periosteum, and internally, but to a less extent, between the medullary membrane and the bone. The great abundance of the effusion, its position round the fragments, and the lifting of the periosteum, are all displayed in the annexed figure (15), of a fractured tibia in a rabbit. (Mus. Coll. Surg. 420.) So early as the fourth day this exudation contains cartilage cells, which rapidly multiply, so that by the eighth or tenth day it exhibits the structure of soft cartilage.

Fig. 15.*

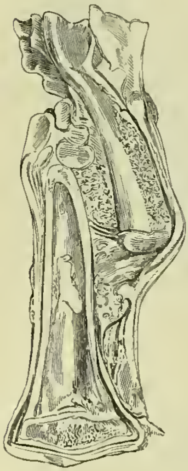
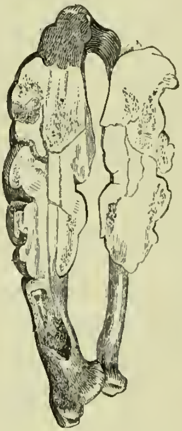


Fig. 16.†



In the second period, from the tenth to the twenty-fifth day, while the muscles are separating from the periosteum, the soft external or provisional callus gradually acquires firmness, with the perfect structure of cartilage or fibro-cartilage. It is frequently contracted immediately opposite the fracture, and adheres closely to the surfaces of bone beneath. The same change takes place in the internal callus, or 'plug,' which gradually fills up and obliterates the medullary canal, being blended with the substance between the fragments.

In the next stage, both the external and internal callus ossify, ossification commencing in the parts farthest from the fracture. The period occupied by this change is variable. According to Lebert, bone-corpuscles are visible in the callus, especially near to the old bone, so early as the tenth day, and ossification is complete by the thirty-third. Dupuytren, however, assigns it to the period between the twenty-fifth and forty-eighth, or even the sixtieth day. The new bone at first consists of spongy tissue, but in the fourth period, from the fiftieth day to the fifth or sixth month, it is stated to become compact. In by far the majority of cases, however, this change does not take place: the callus remains spongy, or becomes compact only on its surface. How great an extent of callus may thus be converted is seen in Fig. 16, representing the ossified radius and ulna of a small bird, where, on the ulna at least, the callus is considerably larger than the original bone. (From Mus. Coll. Surg. No. 426.)

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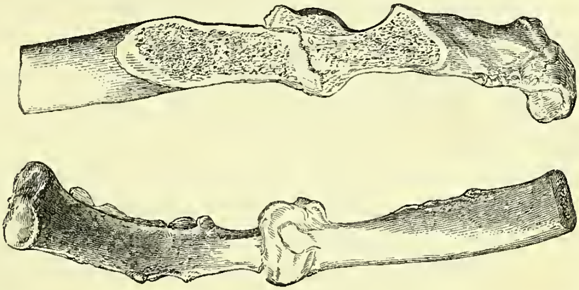
* Fracture of the tibia of a rabbit, to show the first stage of union by provisional callus. From a preparation in the Museum of the Royal College of Surgeons.

† Ossification of provisional callus. Museum of the Royal College of Surgeons.

Lastly, about the fifth or sixth month, the intermediate tissue ossifies, forming the permanent bond of union, or permanent callus. In a very few cases, however, there appears to be an arrest of development previously to this last change; so that there is never any direct union of the fragments, which remain in the condition of the human rib (three months after fracture) represented in Fig. 17 (from St. George's Hosp. Mus. I. 72), where the line of fracture is still occupied by fibrous tissue only, surrounded by a large ossified callus. Malgaigne incorrectly represents this as a usual and normal occurrence, imagining that the permanent callus is met with only when the external has been absorbed by pressure.

Fig. 17.*



The only bones which normally and constantly unite by this process in man are the ribs. Occasionally it is seen in the clavicle and humerus; rarely in the tibia, fibula, and other bones. In children, however, it is more frequent; according to Hamilton, almost constant. Although Dupuytren entertained the idea that the provisional callus was intended as a temporary support during the early stages of union, there appears no just ground for regarding it in any other light than as the natural result of the irritation generated by the perpetual movements of fragments invested by much areolar tissue.* For in certain fractures, as those of the olecranon, acromion, coracoid, and cranium, it is rarely met with, only when there has been excessive irritation; and never in the fractures of parts surrounded by synovial membrane, although in them it would be of especial service for the supposed purpose. Moreover its great extent in some instances, and its somewhat capricious distribution in such a case as that represented in Fig. 16, show that it is the result simply of irritation. The tardy ossification of the permanent intermediate tissue may arise from the mechanical obstruction of the external ring of bone.

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* Union by provisional callus in the human subject. The provisional callus has ossified; the fractured ends being still united by fibrous tissue only. From St. George's Hospital Museum.

A condition in many respects analogous to that just described is met with in the repair of certain fractures in the neighbourhood of joints, especially of the hip-joint, when accompanied by much deformity, in which strengthening buttresses of bone are thrown out, on the concave side, manifestly as the result of irritation.

In inflamed simple and in compound fractures a third mode of union is met with, viz. union by granulations.

In compound fractures there is usually greater injury to the soft parts than in simple. Either they are crushed and their vital powers annihilated at once, or great inflammation is followed by extensive suppuration and sloughing. The periosteum is generally torn away from the bone, and the medullary membrane is either crushed and lacerated or involved in the subsequent inflammation. The inflammatory effusion among the deep muscles generates a capsule around the fragments, arising from the healthy bone beyond the torn periosteum. In the majority of cases, the ends of the bone, thus lying in a closed abscess and bathed in pus, die, the necrosis being limited by the extent to which the periosteum and medullary membrane are torn away. After the separation of the sequestrum, granulations spring up from the exposed surfaces and ossify. If the necrosis does not involve the whole thickness of the bone, partial and imperfect union may take place before the separation. Generally the slow exfoliation and the lengthened suppuration so weaken the powers of the part and of the constitution that ossification is tedious and may be altogether arrested. Even when there is no necrosis the progress is in all other respects the same. After the completion of union the adaptation of the fragments is generally less perfect than after simple fracture; morbid deposits of bone from inflammation are more frequent and more irregular, and there is greater adhesion of the tissues one to another. This is especially observable after compound fractures of superficial bones, as the tibia, to which the skin is often long adherent.

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* Paget suggests a second reason for its constancy in animals—a greater general tendency in them to the production of bone.—*Lectures on Surg. Path.* vol. i. p. 240.

The changes which occur in the latter part of the process of repair, viz. the shaping or modelling of the bone after its union is complete, so as to restore it as nearly as possible to its original condition, are these: 1. All rude and unnecessary projections are removed by absorption. The sharp points left by the overlapping of ill-united fractures, whether deep or superficial, are first softened by the disappearance of their earthy matter, and subsequently removed and rounded off. It has been questioned whether, after the repair by provisional callus, this callus, once ossified, is absorbed. The absorption is certainly not complete. In most ribs that have been broken there remains more or less enlargement at the seat of fracture. M. Lambron refers all absorption to the continual pressure and friction of the muscles.* 2. When the fragments overlap, the exposed ends of the medullary canal are closed by a layer of compact tissue (Fig. 12). 3. The new bone, at first uniform in structure, has to acquire the firmness and strength of compact bone externally, and internally to be hollowed for a new medullary canal. Whatever the relative position of the fragments, the medullary canal usually becomes continuous in the two. Even where they overlap, their compact walls are absorbed, and the cancellous tissue and canal of the one become eventually continuous with those of the other. In the clavicle here represented (Fig. 18, from St. George's Hosp. Mus. I. 87, and I. 88) the restoration of the cancellous tissue is almost perfect, notwithstanding the irritation to which the part must have been subjected during union, as evidenced by the large irregular deposit of new bone externally (Fig. 19). It sometimes happens, however, that the plug which is formed in the process of union by provisional callus remains as a permanent septum. For a long time after union the new bone is more vascular than the old, and contains more animal matter.* Generally, in the course of a year or little more, all the tissues concerned are restored to their normal state, however much their relative positions may be altered.

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* *Thèse Inaug.*, Paris, 1842.

If the coaptation of the fragments is good and union healthy, the old bone itself undergoes no change. Curling, indeed, has endeavoured to show that, in fractures of long bones, the fragment which is cut off from the nutrient artery becomes more or less atrophied; † but his theory has received no support from other observers. But if there is great overlapping, with tedious union, both fragments suffer more or less atrophy; they are shrunken and conical, and their cells enlarged. The same condition may result from other causes of local debility or tedious union.

Fig. 18.‡

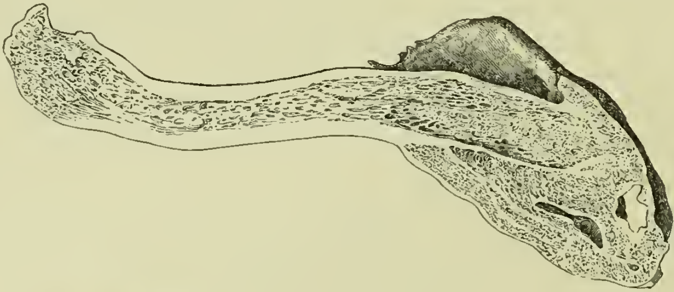
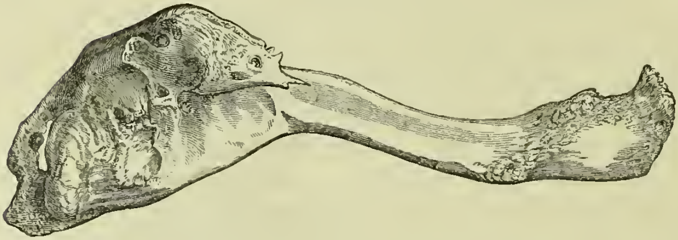


Fig. 19.§



The time requisite for the various stages or for the completion of union can never be predicated with certainty. No deductions from experiments on animals can be applied to man. Only approximate dates can be given. Ossification, in the ordinary mode, in simple fractures, is rarely completed before the ninth or tenth week, even under favourable conditions. This period is subject to variation from many causes : the age of the patient, the size and situation of the broken bone, the nature of the fracture, and the relative position of the fragments.

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* Von Bibra, in *Chem. Unters. über die Knochen, &c.*, 1844, p. 305; and Howship, *Med.-Chir. Trans.* vol. ix. p. 143.

† *Med.-Chir. Trans.* vol. xx. p. 336.

‡ Section of fracture of the clavicle, united with much external deposit of bone—showing the restoration of the cancellous tissue of the bone. From St. George's Hospital Museum.

§ External view of the same preparation.

In infants fractures unite with marvellous rapidity. Ten or twelve days are often sufficient for the forearm or humerus. On the other hand, in old age the period is greatly protracted, in proportion to the want of vigour of the individual. *Cœteris paribus*, the larger a bone, the longer the period it requires for its union. It may be on this account alone that the bones of the lower extremity appear to unite more slowly than those of the upper. But, however this be, the position of the former, throwing upon them much more violence and weight, prolongs the period necessary for the treatment of their fractures, which ordinarily require the retention of apparatus from eight to twelve weeks, while three or four suffice for those of the upper extremity.

The relative position of the surfaces of the fragments has the most marked influence over the rapidity of union. If they overlap, it is proportionately retarded. If, in addition to overlapping, they are more or less separated ; or if they are very oblique and smooth, so that they readily glide one over the other ; or if they touch only by their periosteal sides, nearly double the ordinary time will be required for their union, partly, no doubt, in consequence of the difficulty of maintaining them at rest. Cases of double fracture, in which it is difficult or impossible to prevent riding, are always tedious.

Compound fractures demand, on an average, three times the period required for simple. The most tedious are gun-shot wounds, on account of the extensive comminution of the bone, and the damage to the soft parts. Next to them are clean-cut fractures, in which nearly all the tissues are divided.

When there has been actual loss of bone, in consequence either of the removal of splinters or comminuted portions, or of sawing off the end of one of the fragments, the extent of restoration varies in different cases. In most instances it is little or none, and the limb is permanently shortened to the extent of the loss. Many remarkable cases, however, are recorded of the regeneration of large pieces of bone, generally in the tibia. Delamotte mentions one in which no less than six inches of this bone were restored.* In another related by Gooch,† five inches; and in others, two, three, four, or five inches‡ have been replaced. The more favourable cases of this kind occur in young subjects, and the restoration is effected by the ossification of effused lymph. The more it is by granulation the less perfect is it. From the recent experiments of M. Ollier,§ confirmed, as they have been, by others, it appears that the restoration is exactly in proportion to the integrity of the periosteum, the preservation of which membrane is therefore of the first importance in all cases of resection.

Perforations of bone by balls, or other foreign bodies, generally become filled more or less, with new bone. When the perforation is large, bony offshoots from the edges partially, but never completely, close it.

A fracture extending into a joint is never followed by reunion of the articular cartilage. There is always on the second or third day, or even earlier, more or less synovial inflammation. In simple fracture this may subside without further mischief; the bone unites, leaving an interval between the borders of the cartilage, which may or may not be filled with fibrous tissue. In more severe cases, a false membrane may form on the synovial surfaces; or inflammation extends to the cartilage, which is more or less eroded, and a cure is effected by fibrous, or, rarely, by bony, anchylosis. In compound fractures some degree of destruction and subsequent anchylosis is inevitable, in proportion to the size of the joint and the nature of the fracture. Rarely, indeed, does a fractured joint entirely recover its functions.

Separations of epiphyses unite by the same process as fractures. But if the union is vicious, and the separated epiphysis is the head of the humerus or femur, this accident is invariably followed by atrophy of the limb, from imperfect growth of the injured bone; the consequence, apparently, of the partial destruction of the fibrous layer connecting the epiphysis to the shaft (*v.* also p. 40).

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* *Traité Comp. de Chirurgie*, obs. 80.

† *Cases and Prac. Remarks in Surgery*, 1758, p. 97.

‡ Recorded by Phillips, Van Swieten, and Dunn. See *Obs. on Compound Fractures*, in *Med.-Chir. Trans.* vol. xii.

§ *Recherches, Exp.* &c., in Brown-Séquard's *Journ. de la Phys.* Jan. and April 1859.

Ununited fractures.—The process of union may be delayed or completely arrested at any period of its progress. But, inasmuch as the time requisite for consolidation is very variable, and there are no signs by which to determine the precise period of arrest, the distinction between retarded union and non-union is more or less arbitrary. They both acknowledge the same causes, and demand similar treatment.

Certain fractures, from special causes, rarely unite by bone. They are, fracture of the neck of the femur, of the condyles, of the humerus, of the olecranon, coronoid process, and the patella.

Ununited fractures are, fortunately, rare. Amesbury,* indeed, states that he had in 1828 seen fifty-six cases, and some years later ninety; but his experience is quite exceptional. Lonsdale † found that, of 4,000 fractures treated at Middlesex Hospital, only four or five refused to unite; Norris ‡ did not meet with one case out of 946 fractures: the cases which he saw were sent from elsewhere. Liston met with only one in his own practice; and other surgeons give similar testimony. Hamilton reckons that they do not exceed one in 500 cases, and even this estimate appears high. They are more frequent in males than in females. The relative liability of different bones is exhibited in a table of 150 recorded cases drawn up by Norris. Of these, forty-eight occurred in the femur, forty-eight in the humerus, thirty-three in the leg, nineteen in the forearm, and two in the lower jaw. Other bones, however, are not exempt; instances having been met with in the clavicle, ribs, acromion, and even the spine.

The mode of connection of the fragment is of four kinds: 1. In a few cases, they are enclosed in a mass of fibro-cartilage. This may be provisional callus arrested in its development, or the result of subsequent irritation. This variety of union is always painful under rough handling. 2. In others, also, but few in number, and only in anæmic subjects, there is absolute want of uniting medium of any kind. The ends of the bone are atrophied, loose, and very movable. The limb is shortened, and quite powerless. 3. Occasionally a genuine diarthrodial joint is established. A typical illustration of such a joint in the humerus is shown in Fig. 20. (Mus. Coll. Surg. No. 462.) The ends of the fragments are greatly enlarged, each being alternately concave and convex, and fitting accurately to the irregularities of the other. These ends are covered by a smooth fibrous tissue, the whole being surrounded by a strong capsular ligament, represented in the drawing only at the sides. In other cases the ends of the bone are covered with cartilage, or worn down by friction to a hard, or even ivory-like surface. In the preparation in the Museum of the College of Surgeons (No. 469), from which Fig. 21 is taken, and which is described as a fracture of four or five years' standing, the ends of the bone are, as here depicted, studded with cartilage, and enclosed in a large and loose synovial capsule, in which were found a great number of false cartilages. This kind of union is always the result of considerable motion. It is never seen after a com-

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* *Obs. on Nature and Treatment of Fractures*, &c. pt. ii. p. 193, Lond. 1828.

† *Practical Treatise on Fractures*, London, 1838.

‡ 'On the Occurrence of Non-union after Fractures,' *Amer. Journ. of Med. Sci.* Jan. 1842, art. 1: the most complete article for reference on the subject.

Fig. 20.*

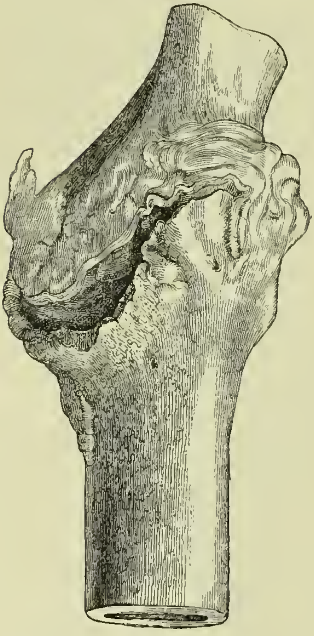
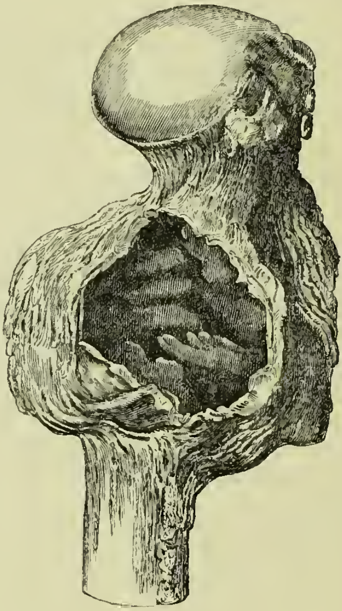


Fig. 21.†



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* False joint after fracture; showing the ends adapted to each other, and united by a capsular ligament. From the Museum of the Royal College of Surgeons.

† False joint after fracture; showing a large and loose synovial capsule containing numerous false cartilages. From the Museum of the Royal College of Surgeons.

pound fracture, when there is always some kind of fibrous connexion. 4. In by far the majority of cases, the union is by fibrous tissue. This tissue firmly adheres to the bone, and is very pliable. In some cases it is so short as to constitute a kind of synchondrosis between the fragments, admitting scarcely any movement. In others it is long and flexible. It may be entire, or separated into two or more bands. The ends of the bone are commonly smooth and rounded off; sometimes they are shrunken and pointed; at others more or less enlarged by accessory bony growths—a circumstance highly favourable to the prognosis. The medullary canal is closed.

It is not always possible to ascertain the actual condition of the part: but the points to be observed, as bearing practically on the treatment, are, the relative positions of the fragments; their mobility; as far as possible, their condition; the degree and nature of the deformity; and the sensitiveness of the part under manipulation.

The causes of non-union are constitutional or local. The former include all those conditions in which the powers of the system are much impaired. They are old age, pregnancy, lactation, syphilis, phthisis, fevers, general cachexia, and scurvy.

General fevers and internal inflammation always arrest the progress of union, and may even cause resoftening after its commencement. It is only when accompanied by unusual debility, as in some cases mentioned by Bonn,* that old age is able to retard it. The same is true of pregnancy, lactation, and syphilis, the influence of which has been doubted by some authors.† Schmucher saw union delayed, in unhealthy or scrofulous subjects, for eight or nine months, and in one case for more than a year.‡ Insufficient food, or the want of an habitual stimulus, will prevent union.§ Brodie refers to the examples of two corpulent patients, one male, the other female, in whom an intentional persistence in low diet for some months previously to the fracture had this result.|| In consequence of bad and insufficient food, almost all the gun-shot fractures which Larrey witnessed in Syria were followed by non-union.¶ It

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* Art. 'Fracture' in *Dict. de Méd.* 1836, t. xiii. p. 402.

† For examples of non-union from these causes, see Norris's paper, supra cit.

‡ *Vermischte chir. Schriften*, B. i. p. 26.

§ 'Cases of Ununited Fracture,' by B. Page, *Med.-Chir. Trans.* 1848, p. 135.

|| *Med. Gaz.* vol. xiii. p. 53, vol. xiv. p. 616.

¶ *Mém. de Chir. mil.* 1812, t. ii. p. 131.

has been traced to the enervation consequent on habitual discharges,* to general dropsy,† to copious bleeding, followed by low diet.‡ Heath, of Newcastle, has noticed that the diet of most of his patients has been deficient in vegetable aliments.§ But the most marked effects of impaired nutrition are witnessed in scurvy; the power of which not merely to prevent union, but to dissolve it months, or even years, after its completion, has been pointed out by Lord Anson,‖ Sir S. Hammick, and Desault.¶

In certain obscure cases, in the absence of apparent cause, non-union has been ascribed to some unknown peculiarity of constitution. Two such cases are recorded by S. Cooper,** and five by Sanson.†† A clue may, perhaps, be given to at least some of them by an observation made by Penel.‡‡ He found the urine of his patient alkaline, and loaded with earthy phosphates. In a few cases of tardy union the author has found these phosphates in excess, but not always with alkaline urine. This condition appears to be due to long confinement.

The local causes are much more numerous. They are either indirect, as inflammation of the soft parts, paralysis, obstructions to the circulation, and local anæmia from bad treatment; or direct, viz. diseases of the bone, the presence of a foreign body, separation of the fragments, and motion.

Local inflammation, or abscess, or an ulcer, usually retards union. Wardrop§§ mentions the case of a sailor with compound fracture of the leg, in whom, on three separate occasions, the uniting medium was resoftened in consequence of attacks of erysipelas. A few instances of non-union from recent paralysis have been met with.‖‖ The result, however, is not constant, at least in paralysis of long standing; for a fractured tibia has been known to unite readily in a man who had been palsied for twenty years.*

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* Marrigues, *Diss. sur la Form. de Cal,* Paris, 1783; and Thierry, *Expérience,* 1841.

† A. Cooper, sup. cit. p. 570.

‡ Hewson, *Jour. du Progrès,* t. ix. p. 161.

§ *Lancet,* 1855, vol. i. p. 611.

‖ *Voyage round the World,* 15th ed. p. 142.

¶ *Journ. de Chir.* t. ii. p. 318.

** *Dict. of Prac. Surg.* 7th ed. 1838, p. 551.

†† *Dict. de Méd. et de Chir. prat.* t. iii., art. 'Articulation Anormale.'

‡‡ *Lond. Med. and Phys. Jour.* vol. xiv. 1805, p. 29.

§§ *Med.-Chir. Trans.* vol. v. p. 378.

‖‖ Travers's *Further Inquiry,* &c. p. 436; and B. Phillips, in *Lond. Med. Gaz.,* May 1840.

Obstruction to the circulation by pressure upon,† or ligature of, the main artery above a fracture occasions considerable delay of union. This was shown by Brodie in numerous experiments on animals.‡ The same is the result of early, tight, or prolonged bandaging. In France, where the treatment by immovable apparatus has been employed much more extensively than in England, it has been found that fractures so treated unite in general but slowly, occasionally not at all;§ and Troja and Duhamel proved experimentally the prejudicial influence of strong pressure over the seat of fracture. Prolonged bandaging or the excessive employment of emollients and refrigerant lotions in the early treatment produces an anæmic condition of the limb, to which Cloquet‖ has given the name of local scurvy. The skin is pale, and deprived of its natural secretion; the cuticle separates; the whole limb is shrunken or œdematous. Sometimes points of ecchymosis appear, which extend more or less over the limb. In compound fractures the granulations become soft and livid, readily bleeding, and secreting a thin, ichorous pus. Of course, consolidation of the fracture is arrested.

Separation of the fragments is manifestly the cause of non-union in fracture of the patella, and probably in all those special fractures which rarely unite by bone. It is, perhaps, the real obstacle to union in those few cases in which a fragment of muscle or tendon,¶ or a large effusion of blood, has been found interposed between the fragments; as, were the interval small, pressure could scarcely fail to cause absorption of the intervening soft tissue. In one singular instance, mentioned by Berard, a fractured clavicle united by two bridges of bone, enclosing the ossified subclavius.

The most constant cause of non-union is undoubtedly motion. Norris was able to trace this cause for twenty-two out of forty-four cases, and suspected it in others. Amesbury goes much farther. He maintains that it is the cause in almost all cases, and that it is due generally to the inadequacy of the ordinary apparatus. That this is an exaggeration is shown by the facility with which most fractures unite under ordinary, or even bad treatment; by the rarity of non-union in the ribs and clavicle, or after double or compound fractures; and by the occasional reabsorption of the callus from fevers. To prevent union, the motion must be considerable and long continued. To the influence of certain powerful muscles, as the deltoid and psoas, is due the frequency of non-union in the humerus and femur.

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* Busk, *Lond. Med. Gaz.* 1840, p. 97.

† Davies, in *Lancet*, Feb. 5, 1859.

‡ *Med. Gaz.* vol. xiv. sup. cit.

§ *Réponse à M. Rognetta*, &c., *Gaz. méd.* 1831, p. 630.

‖ Art. 'Fracture' in *Dict. de Méd.* sup. cit.

¶ S. Cooper, in *Dict. of Pract. Surg.* 1838, p. 551; and Stanley, in *Lancet* for 1854, vol. i.

Numerous measures have been devised for the cure of pseudarthroses. But, as the distinction between the delay and arrest of the process of union is in all cases doubtful, it is only after the failure of the milder methods that recourse to operation is justifiable. For practical purposes, indeed, the failure of all means short of operation may be regarded as the only absolute proof of such arrest.

The indications for treatment are four. 1. To remove all local impediments, as foreign bodies, dead bone, and disease of the bone or soft parts. 2. To improve the general health. 3. To ensure the primary conditions of union, immobility and contact of the fragments. 4. To excite, by artificial means, the suspended reparative action between and around the fragments.

The various constitutional cachexiæ must of course be met by their own special remedies. Change of air and scene, and improved living, are often all-sufficient treatment. In cases of debility, with excessive secretion of phosphates, as in Penel's case, mineral acids and tonics are required. Mercury, given to salivation, as first recommended by Fleury, even in cases where there is no suspicion of syphilis, has been much vaunted by some, and has occasionally been of service where other means have failed.* It has, however, repeatedly been found useless, and can be tried with safety only on plethoric patients.

The local means which have been adopted to answer the remaining indications are: 1. Rest and pressure. 2. External stimulants. 3. Friction. 4. Setons. 5. Acupuncture. 6. Galvanism. 7. Subcutaneous incision. 8. Perforation of the bone. 9. Resection, with or without ligature of the fragments. 10. Resection, with preservation of the periosteum. 11. Rasping the ends of the bone. 12. Cauterisation. 13. Stimulant injection. 14. Dieffenbach's operation.

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* Hammick, op. cit.; and B. Cooper, in *Guy's Hosp. Reports,* 1837, p. 399.

Amesbury, following out his own doctrine, maintains that, except in the rare cases of preternatual joint, or when union is prevented by the presence of a foreign body or diseased bone, rest and pressure are almost invariably sufficient for the cure. By this method he has succeeded with fractures of from ten weeks' to sixteen months' standing, even after setons and other measures had failed. Although others have not found this treatment so universally successful, it must of course, in the great majority of cases, take precedence of any other. It is specially applicable in those cases where non-union depends on motion or malposition, or on deficient local action from general anæmia, without atrophy of the fragments, and in all cases attended with thickening and tenderness at the seat of fracture.

If the limb be healthy, Amesbury's or some other form of immovable apparatus is the most efficacious. But if it be œdematous, or inflamed, or atrophied, movable splints are better. There are cases, especially in children, in which it is scarcely possible to obtain perfect immobility except by including in the apparatus the adjoining part of the trunk. Lateral pressure may be made by bandage and compresses; longitudinal by crutched splints in the upper extremity, by straps and collars in the lower.*

In most cases it is not enough to keep the fragments in close contact. A certain amount of stimulus is requisite. For this purpose, Amesbury directs that the pressure be sufficiently great to produce pain in the course of a few days. The duration of treatment in his cases varied from three to ten weeks. In others, where rest alone has been relied on, four or five months have sometimes been found necessary.†

The efficacy of all local measures appears to depend, not so much on the irritation of the bone itself, as on the action which they arouse in the soft parts surrounding and connecting the fragments. It has happened in cases of tardy union, that an accidental bruise‡ or attack of erysipelas§ has hastened the process. It is on this principle that external applications are recommended. Stimulant lotions,* blisters,† iodine,‡ galvanism, issues, and cautery, have all been used with occasional success. If the limb is atrophied, and in the condition of local scurvy, exposure to air and light, friction, stimulant embrocations, and galvanism are of the greatest service. Under other circumstances, the advantages of any of these external applications are confined to cases of simply tardy union in superficial bones. In these they are of undoubted benefit, but only when used at an early period, within eight or ten weeks after the fracture. The most tested, and probably the most efficacious, are blisters. Walker employed a succession of small ones; Velpeau, with equal success, or nearly so, a few large ones. Malgaigne suggests the substitution of sinapism as being more rapid, but does not appear to have put his suggestion to the proof. Birch § found galvanism of service in two cases. Mott|| tried it without benefit. Twice, too, a caustic-potash issue was employed with success by Hartshorne.¶

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* See Amesbury's *Treatise* for detailed description of his apparatus, as applied to different limbs.

† Bonnet, *Gaz. méd.* Sept. 1839.

‡ Wardrop, *Med.-Chir. Trans.* vol. v. sup. cit.

§ Seerig, *De Pseudarthrosi de fracturâ proficiscente,* 1838.

Friction of the fragments is somewhat more stimulating than mere pressure. There are two modes of effecting it. The usual method is manual; rubbing the fragments against one another for some minutes, till a degree of uneasiness or even pain is produced. It may be repeated, if necessary, daily, till the part becomes tender and painful. It is intended to break down the connecting bands, and even roughen the surfaces of the bone. The other method, applicable only to the lower extremity, recommended first by White,** and afterwards adopted by Hunter, Champion, and many others,†† is to envelop the limb in a firm apparatus, and direct the patient to walk on it. In White's case, a large abscess formed in the thigh; this, however, did not prevent a favourable result, and is the only instance in which positive harm has resulted from the treatment. In another case

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* Cloquet, in art. sup. cit., and Jobert. See Fleury's Memoir, 'Quelques considérations sur les causes qui peuvent retarder,' &c., *Archives de Médecine*, août 1837.

† Walker, *Lond. Med. and Phys. Journ.* xxxii. p. 470; Brodie, sup. cit.; and Velpeau, *Méd. opér.*

‡ Buchanan, *Essay on a new Mode of Treatment for Diseased Joints and the Non-union of Fractures*, London, 1828; also Crosse and Blackwell, see Norris.

§ In Steevens's translation of Boyer's work.

|| *Med. and Surg. Reg.* part ii. p. 375.

¶ *Philad. Med. Recorder*, April 1826.

** *Cases in Surgery*, 1770, p. 75.

†† Velpeau, *Méd. opér.* 2nd ed. t. ii. p. 583.

the apparatus could not be borne.* Friction should always be tried, as supplementary to rest and pressure, before stronger measures are adopted. Its greatest triumphs are in cases of general anæmia, when from the first there has been little or no action, and the fragments are loose and movable, as in a scrofulous lad under the care of Sir S. Hammick. It is of course contra-indicated by the presence of inflammation.

Dr. Physick† was the first to attempt the cure of non-union by passing a seton between the fragments; though the first idea of it has been ascribed to Winslow. Since that time setons have been extensively employed, with a considerable share of success. Of the 150 cases tabulated by Norris, they were tried at some period of the treatment in seventy-two, in only twenty-eight of which they failed. Although Dr. Physick, according to his nephew's report,‡ generally succeeded by this plan in the upper extremity, and failed in the lower, subsequent experience has shown that it is specially adapted to fractures of the leg and forearm, and smaller bones. In these, failure is rare, Norris's table pointing to only one out of twenty-two cases; whereas in the humerus and femur, the unsuccessful cases slightly preponderate. The duration of the treatment has varied greatly. Physick allowed the seton to remain four or five months, or even more; in fact, till union was either completed or hopeless. Earle left it for seven weeks;§ Wardrop recommends two or three weeks; and Liston eight or ten days.‖ No arbitrary time can be fixed; but the object being to excite local action, and not to exhaust the powers by prolonged suppuration, which, indeed, is more likely (as in compound fractures) to retard than to promote union, besides increasing the risk of erysipelas, the seton should be removed as soon as there is considerable solidification in the neighbourhood. If there is no suppuration, so much the better. Adams mentions a case in which the seton was left in only four days, and was yet successful.¶ Its prolonged use does, indeed, appear to have impeded union in some instances, especially in the large bones.** Liston records a case where it was left in the humerus for thirteen months:[*] a useless arm was the result.

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* Sue, in Desault's *Clinique*, t. ii. p. 312.

† *New York Med. Repository*, vol. i. 1804.

‡ Brodie, loc. cit.

§ *Med.-Chir. Trans.* vol. xii. 1823, p. 190.

‖ *Practical Surgery*, 4th ed. 1846, p. 99.

¶ *Med. Times and Gaz.* 1851, vol. ii. p. 391.

** Malgaigne, p. 311, sup. cit.

It appears from the statistics to be a matter of perfect indifference whether the bone is reached by previous incision or not. It is simply a question of convenience. Weinhold recommended a wedge-shaped seton, as being, in his opinion, both safer and more efficacious.[†] Its effect may also be increased by smearing it with red precipitate or other irritant,[‡] or by combining its use with that of friction, or even with some more serious operation.

The treatment by seton is not altogether free from risk. Twice it has been fatal. Many cases have been endangered by attacks of erysipelas or profuse suppuration. In Wardrop's case[§] there was severe hæmorrhage from a wounded artery. In another, under Stansfield,[||] the seton gave rise to intense pain. Its use is precluded by great separation or excessive mal-position of the fragments, by the absence of uniting medium between them, by irregular deposits of bone, by the proximity of a joint, or by the antiquity of the fracture. In most other cases, especially in the leg or forearm, it is admissible.

In two cases in the humerus, and one in the forearm, in which he was unable to introduce a seton between the fragments, Oppenheim[¶] passed two, one on either side, so as to create irritation in their immediate neighbourhood. He recommends the operation as more effectual than the ordinary mode, and Malgaigne considers it more rational. It is, at any rate, equally successful.

Analogous to setons are ligatures, passed round the tissue connecting the fragments, and gradually tightened till they completely cut through it, thus stimulating successively different portions. Sommé[**] used a silver wire for the purpose, and Seerig[††] a waxed thread.

In one case, in the lower fourth of the femur, Malgaigne[‡‡] endeavoured to pass acupuncture needles between the fragments; but they were so close that, although he thrust in thirty-six directions, he was not able to introduce even one needle. Wiesel* was more successful in the forearm. He operated first on the ulna, and afterwards on the radius. The needles completely traversed the false joint, and were left in for six days, till they caused pain and swelling. The cure was complete in six weeks.

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[*] Supra cit. p. 100.

[†] *Hufeland's Journal*, May 1826.

[‡] Weinhold, ut supra; and Liston, in *Lancet*, April 30, 1836.

[§] Supra cit.

[||] Mentioned by Brodie.

[¶] *Ueber die Behandlungsweisen der Pseudarthrosen*, &c., in *Hamb. Zeitschrift*, vol. v. pt. 1.

[**] *Med.-Chir. Trans.* vol. xvi. part 1, 1830, p. 36.

[††] *Arch. gén. de Méd.*, Jan. 1839, p. 105.

[‡‡] *Traité des Frac.*, 1847, p. 307.

By means of needles a current of galvanism has been passed through the connecting ligament by Brennan† and Lente‡ of New York. Both these authors considered it of service. It was tried by Square§ without effect.

C. Bell|| proposed to wound and irritate the ends of the bone by the subcutaneous introduction of a pointed instrument; but he had no opportunity of carrying out his idea. More recently, M. Blandin,¶ having divided the connecting tissue with a tendon-knife, scraped the fragments with its sharp edge; but erysipelas and abscess were the sole results. A great improvement in this operation was effected by Miller,** who confines himself to the laceration and irritation of the connecting tissue, by passing through it, in various directions, a double-edged bistoury or tendon-knife. Brainard†† employs for this purpose an awl-shaped perforator; and in cases of overlapping he perforates the fragments themselves in two or three places, making, however, only one small wound in the skin. The treatment has met with great success, and is applicable to most cases, but especially where the connecting tissue is long and loose. Miller suggests that it might be advantageously combined with galvanism.

Resection, scraping, and cauterisation aim at more than the preceding operations. Their object, besides irritation, is to remove the effete and indolent tissue covering the ends of the fragments, and to place them in the condition of a recent compound fracture.

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* *Journ. de Chirurgie*, 1844, p. 85.

† *Monthly Journ. Med. Sci.*, Feb. 1848.

‡ *New-York Journ. Med.*, Nov. 1850.

§ *Med. Times*, 1851, vol. ii. p. 300.

|| *Oper. Surg.* 2nd ed. 1814, vol. ii. p. 326.

¶ *Gaz. des Hôpitaux*, 1844, pp. 557, 569.

** Miller's *Principles of Surgery*, 2nd ed., 1850.

†† *Trans. Amer. Med. Assoc.* vol. vii. 1854; and in Hamilton *on Fractures*, 1860.

Resection of the fragments was first put in practice by White.[*] He operated with success on the humerus and tibia. In the latter case, in consequence of the difficulty and danger of reaching the lower fragment, he excised the end of the upper one alone, irritating the other by scraping the periosteum, and destroying the soft tissue which prevented their approximation by butter of antimony. This difficulty is one of frequent occurrence in the performance of this operation; and Dupuytren,[†] on the strength of two successful cases, suggested that all the efficacy of the operation may be obtained by the resection of one fragment, and rasping the other. For many years resection was regarded with much favour. Of Norris's 150 cases, it was performed, on one or both fragments, in no less than sixty-four; in thirty-seven successfully. In the leg it never failed; rarely in the forearm. But with the humerus and femur the results were far otherwise. Of twenty-seven operations on the humerus, eleven only were followed by union, two were fatal. Of seventeen on the femur, ten were successful, but four fatal. On these bones, indeed, the operation is encompassed with difficulties and dangers. In one case it lasted two hours;[‡] in another,[§] after an hour's duration, it was immediately followed by fatal convulsions. Rowlands[||] was so struck with the difficulties he had to encounter in the thigh, that he admits he should hesitate to recommend it. In fact, for the larger bones its dangers are so conspicuous, that it is now universally abandoned. But in others, especially the superficial bones, it is still occasionally adopted. Where there is a true diarthrodial joint, especially if the ends of the fragments are enlarged, or rough with deposit, it is the best, perhaps the only admissible, operation. Next to these, it is most applicable to cases of long standing, or in which the fragments are loose and widely separated, or greatly overlapping. It is absolutely precluded by the neighbourhood of a joint.

In some instances there has been great difficulty in keeping the fragments in contact or at rest after the operation. Three methods have been devised for the purpose. 1. M. Roux* locked the point of one fragment into the medullary canal of the other; the operation failed in consequence of a fall. 2. The fragments have been cut obliquely, so as to present a larger surface for mutual contact and support, and to admit of lateral pressure. This mode of section produces less shortening than the transverse.† 3. The third method is suture, either by waxed thread, used unsuccessfully by Flaubert; or, better, by silver-wire, which was first employed by Horeau,‡ afterwards, with success, by Rogers, Mott, Laugier, and others, on the humerus, femur, and radius.§ This practice, though denounced by Norris, who states that he has known an instance in which it was fatal, appears to increase the efficacy, but not the danger, of resection. In an operation on the lower jaw, in which this mode of retention is essential, Dupuytren passed the connecting wire round the teeth.||

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[*] *Cases in Surgery, with Remarks,* Lond. 1770.

[†] 'Resection de la Mâchoire inf.,' *Leç. Orales,* t. iv. p. 658.

[‡] Walb, *Amer. Journ. Med. Sci.* xvii. p. 46.

[§] Vallet, *Thèse inaug.,* Strasb. 1817; and in Velpeau's *Méd. opérat.* t. ii.

[||] *Med.-Chir. Trans.* vol. ii. 1813.

Jordan ascribes the failure of resection to the removal of the periosteum. He, therefore, by means of some blunt instrument, as the handle of a scalpel, dissects this membrane from the portions of bone which he is about to remove, and leaves the two empty pouches passed one within the other, and, in some cases, connected by suture, to form new bone. The suggestion is undoubtedly theoretically sound. Its practical value remains, however, to be proved. In two of the three cases which Jordan records, it failed of success; and he admits its failure in the hands of M. Sédillot.¶

In an ununited fracture of the humerus, Hunter effected a cure by opening the synovial cavity, and irritating its interior with a spatula.** This is the only case of the kind on record; but scraping the fragments, originally suggested by White, has been occasionally adopted independently of resection. The results are not encouraging. Failure has been more frequent

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* Mentioned by Berard in art. 'Fracture,' sup. cit.

† Laugier, Mém. read to Acad. des Sciences, April 1855.

‡ *Journ. de Méd. Clin. et Phar.* vol. x. p. 195.

§ Laloy, 'De la Suture des Os,' &c., *Thèse inaug.*, Paris, 1839.

|| 'Resection de la Mâchoire inf.,' in *Leç. Or.* t. iv. p. 658.

¶ *Traitement des Pseudarthroses par l'autoplastie périostique,* Jos. Jordan, Paris, 1860.

** Referred to by Brodie on the authority of Home. See also Hunter's *Works,* Palmer's ed. 1835, vol. i. p. 504.

than success, and twice the operation has been fatal.* Brodie plugged the wound with lint, and failed; but his proceeding has been successfully imitated by Davis.†

Cauterisation is a less dangerous operation, though not often employed. Different caustics have been used; caustic potash, which is the best, by Cline,‡ Earle,§ and others; nitric acid by Ollenroth;‖ chloride of antimony by White and Weilinger;¶ nitrate of silver by Kirkbride.** In one of Earle's cases and in White's, there was a slight exfoliation of bone; but this is not usual. Cauterisation is most applicable to old cases, when the fragments are covered with fibro-cartilage, or with a genuine false joint.

A mild species of actual cautery was used by Mayor †† on the femur. He passed several times between the fragments a steel probe heated in boiling water. It produced profuse suppuration and union. The actual cautery was once used by Petit.

In a case of non-union of the humerus, in which there was a fistulous opening, Hulse ‡‡ found the daily injection of a stimulating liquid of service, both to hasten the separation of the dead bone and stimulate the growth of new.

In 1845 Dieffenbach introduced an operation which bids fair, in most cases, to supersede the severer measures just noticed. Taking advantage of the fact pointed out by Duhamel and Flourens, that inert foreign bodies lodged in bone become surrounded by abundant osseous deposit, he drills three or four holes, penetrating as far as the medullary canal, near the end of each fragment, into which he forcibly drives ivory pegs. The pegs, projecting from the bone, are left from ten to twelve days or more; that is, till their presence has given rise to considerable swelling. Union is completed in from ten to twelve weeks. Dieffenbach himself appears to have met with great success from this operation, even on the humerus and femur.* In England it has been performed successfully on the femur, tibia, humerus, and ulna.† It has, however, met with reverses. The first time it was tried, by Square ‡ of Plymouth on the femur, it utterly failed. The case, however, was a most unfavourable one, and eventually the limb had to be amputated. Bowman § also failed in the leg, in a case equally unfavourable from excessive deformity. The operation has been followed, in different cases, by fever, erysipelas, hæmorrhage, and profuse suppuration, but does not appear to have been fatal, offering, in this respect, a favourable contrast to resection, due probably to the circumstance that it does not expose the end of the medullary canal. In one case || the operation on the femur was followed by union, leaving, however, a sinus, and succeeded, some weeks later, by erythema, profuse suppuration, and hectic, necessitating amputation.

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* In one of these a seton was used also. See Malgaigne's *Traité,* sup. cit. p. 317.

† *Lancet* for Feb. 5, 1859.

‡ South's *Transl. of Chelius' Surgery,* vol. i. p. 591.

§ *Med.-Chir. Trans.* vol. xii. p. 190.

‖ Bernstein, *Ueber Verrenkungen,* &c., p. 280.

¶ *Rust's Magazin,* vol. xxxiv. p. 330.

** *Amer. Journ. of Med. Sci.,* Feb. 1835.

†† *Nouveau Système de Déligation,* &c., Geneva, 1832.

‡‡ *Amer. Journ. of Med. Sci.,* Feb. 1834.

In an operation on the femur, Stanley connected the fragments by a silver wire, in addition to inserting the pegs.¶ The result is not given.

The above operations are practically divisible into two classes: those which are followed by suppuration, and those which are not. The latter must, of course, in all cases in which they are likely to be sufficient, take precedence. The circumstances by which the selection must be guided are the situation and condition of the false joint, and the length of time that has elapsed since the fracture. Special indications have been noticed under the individual operations. Apart from them, where rest and friction, aided, if possible, by external stimulants, have been found insufficient for the cure, Miller's or Brainard's operation deserves the first trial; next to that, some form of seton; and, as a last measure, Dieffenbach's operation. In the humerus and femur it will generally be advisable to omit the seton, and pass at once to Dieffenbach's plan. If the fragments are covered by a very dense tissue, it may be removed, as an accessory measure, either by the knife or caustic.

It is to be observed that no severe operation will be justifiable

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[*] Dr. Bushnan's report in *Med. Times and Gazette,* vol. xv. 1847, p. 298.

[†] See *Lancet,* 1851, vol. ii. p. 344; 1852, vol. ii. pp. 152, 154; 1855, vol. ii. p. 279: also *British Med. Journ.,* 1859, p. 885.

[‡] *Med. Times and Gazette,* 1851, vol. ii. p. 300.

[§] *Lancet,* 1852, vol. ii. p. 153.

[||] *Edin. Monthly Journ.,* March 1854.

[¶] Stanley, *Lancet,* 1854, vol. i.

unless the inconvenience resulting from the non-union is considerable. In some cases, as in the ribs, it is of no practical consequence. In others the new joint supersedes an old one. This has happened after a fracture two inches above the elbow,* and frequently in the neck of the femur. In others, the slight inconvenience is easily and abundantly remedied by an artificial support. Larrey, indeed, recommends this course to be adopted whenever the simple means of cure fail.† In a few cases, where a lost portion of the tibia has not been restored, as in three witnessed by Sir A. Cooper, its place has to a great extent been supplied by a large increase of the fibula.

There are a few cases in which, in consequence either of hectic, or of the great encumbrance of a useless limb, on which all operations have failed, amputation is the only resource.

Diseased and deformed union.—The new bone is of course liable to all the diseases of bone. The two most frequent and most troublesome are long-continued pain, analogous to the neuralgia of cicatrices in soft parts; and excessive exuberance, the result of ostitis.‡

There are three species of deformity resulting from malunion: 1. Junction with permanent displacement, either angular or rotatory, or shortening. 2. Union of two contiguous bones. 3. Projection of one of the fragments.

For the removal of the first kind of deformity four methods have been devised: reduction by means of extension and compression, refracture, section, and resection.

Extension is made, as in the original reduction of fractures, by the hand, or by the assistance of lacs and pulleys, or, gradually, by means of splints. Compression, too, may be applied gradually or suddenly. Gradual compression is made by splints or special apparatus. A splint may be placed opposite the concavity of the angle, and the bone drawn towards it; or it may be fixed to one fragment on the convex side, acting as a lever to which the other is to be drawn; or the projecting angle may be pressed between two opposing splints. The bandages must be repeatedly tightened. Special apparatus of curved splints, straps, and tourniquet-pads have been used, but are rarely, if ever, necessary.*

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* *Med. Times and Gaz.*, 1851, vol. ii. p. 221.

† *Clin. Chirurg.* vol. iii. p. 461.

‡ 'Des Accidents consécutifs aux Fractures,' par M. Guyot, in *Arch. de Méd.* Feb. 1836.

The apparatus, combining pressure and extension, must be worn for from twenty-one to twenty-eight, or even forty days. Sometimes it is sufficient, after two or three weeks, to continue extension alone. By this treatment deformity has been remedied in numerous fractures: in some of twenty-five, twenty-nine, fifty-nine days', or even as much as four or five months' standing. Dupuytren thinks that the union will not yield to extension beyond the sixtieth day; but pressure may be of use much later.†

Sudden forced compression has been sometimes employed; but, except in those cases where it has been used at a comparatively early period, it appears to produce a species of partial fracture. Where reduction cannot be obtained at the first trial, it may be repeated in two or three days.‡

Refracture is effected gradually, during extension, pressure being made either by the hands or knee, or, in difficult cases, by a screw-press.§ Skey manages it readily by leaning the weight of his body on the end of the limb, projecting beyond the edge of a board or bed. The fracture is facilitated by bending the limb alternately in different directions, and, when there is only one bone, by rotation. The old practice of breaking it by a hammer, or by sudden pressure across a stick, is justly discarded.

The time during which a united bone admits of refracture varies greatly, even to the extent of many weeks. It depends on the age and health of the patient, the extent of uniting surface, the position of the fragments; in fact, on all those circumstances which influence the rapidity and perfection of the healing process. The cases of deformity for which the operation is required are the very cases in which union is ordinarily most protracted; and long after it is sufficiently firm to admit of free use of the limb, it may be dissolved by force without difficulty. Moreover, in young subjects, in whom these deformities are most frequent, refracture is attended with the least difficulty. Œsterlen, however, did not attempt it in any case beyond the twenty-fourth week;[*] and Bosch, in spite of the power of his screw, recommended six or six and a half months as the extreme limit. But Skey operated once on the leg, in a boy æt. 15, thirteen months after the fracture.[†] In that case he found it necessary to divide the tendo Achillis before he was able to make extension, and even then the limb remained shortened to the extent of three-quarters of an inch.

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* Jacquemin, *Thèse inaug.*, Paris, 1822.

† 'De la Formation du Cal; Moyens de remédier au cal vicieux ou difforme,' *Leç. Orales*, t. iv. art. 5, p. 130.

‡ A. Thierry, 'Du Redressement des Os fracturés,' *Exp.* Nov. 1841.

§ As used by Bosch, of Augsburg, described by Œsterlen.

Four objections have been raised to this operation. 1. The danger of breaking the bone in the wrong place. Œsterlen and Skey, however, show that this danger is chimerical, the new bone being for many months more spongy and more fragile than the old. This dreaded accident has never happened; and, moreover, accidental refracture, which has taken place in some cases after two or three years, is always in the same place as the first, and the same has always occurred in experiments on animals. 2. The fear of inflammation and abscess, in consequence of laceration of the periosteum and soft parts. But all such accidents have been safely overcome in the first fracture, when they were necessarily more severe. Skey refers to a case in which, without effecting his purpose, he had recourse to considerable violence; the only evil effects of which were slight bruising and stiffness, which passed off in two or three days. 3. The separation of the fragments by an interval which could not be filled by bone. The cases are very few, however, to which this objection could apply, and even in them considerable amelioration of the deformity might be effected. 4. The fear that, in cases of overlapping, the cicatrised ends of the fragments will be incapable of uniting. This fear, however, is unsupported by facts; the deformity is not commonly accompanied by deficiency of healing power; and in many cases the new fracture has appeared to unite even more readily than the old.

The operation has not always been free from danger. Cases fatal from its violence are recorded by Guy de Chauliac, Morgagni,[‡] and Laugier.[§] Of course it is justifiable only when it is indispensable to the utility of the limb, when it can be undertaken without difficulty or danger, and the deformity was attributable to causes which can be avoided in the treatment of the second fracture, and only after all practicable means of reduction by extension and compression have been tried without success. With these restrictions, it may be resorted to, in the upper extremity, when shortening of the forearm is accompanied by loss of muscular power and inability to rotate; in the lower extremity, for extreme lameness, either from shortening or angularity; and, in either limb, for deformity accompanied by severe permanent pain, the result of pressure or displacement of nerves, and not amenable to other treatment.

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[*] *Sur la Rupture du Cal, ou Méthode sûre de rompre les Os mal réduits,* par J. F. Œsterlen, traduit de l'Allemand par J. C. Maurer, Paris, 1828.

[†] 'Cases of Refracture of Bone,' *Med.-Chir. Trans.* vol. xlii. p. 23.

[‡] *De Sed. et Causis Morb.* epist. lvi.

[§] '*Des Cals difformes et des Opérations qu'ils réclament,*' *Thèse du Conc.* 1841, p. 62.

If the union is too solid to admit of rupture, it may be divided by cutting. This has been done more than once. It is, of course, a serious operation, only justifiable in extreme cases of deformity. It was performed successfully on the tibia by Key and A. Cooper in 1839. Quite recently Lister has recorded a very successful operation of the kind on the leg. A fracture of both bones, two inches above the ankle, had united with great displacement of the foot backwards and eversion, rendering the limb absolutely useless. Trusting to the antiseptic treatment to obviate the great risks of producing a compound fracture into the ankle joint, he cut down on the bones, and having divided them with cutting pliers, restored the foot to its proper position, which, however, he was unable to do till he had divided the tendo Achillis, the muscles of the calf and of the sole of the foot being contracted through the long-continued displacement. Fresh union of the bones followed in about six weeks.*

Resection of one or both fragments has been rarely resorted to. M. Clémot removed an angular piece of bone from a deformed femur in an infant of forty days old.†

Union of contiguous bones may take place in the forearm, the leg, or between the ribs. In the leg it is of course unimportant; and in the ribs, though an impediment to free respiration, it cannot be touched. In the forearm it might be remedied by rupture or section; but it does not appear that more than one instance of such an operation is recorded.‡

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* *Brit. Med. Journ.*, Oct. 31, 1868, p. 462.

† Clémot, *Mém. sur la Resection du Fémur, Acad. de Méd.*, 1836.

‡ By Gardeil; quoted in Malgaigne's work, sup. cit. p. 342.

The projecting point of one of the fragments may be the source of much irritation and inconvenience. Generally such projections are removed by absorption; but occasionally it is not so. They may in that case be removed by the saw or nippers. A few operations of the kind are mentioned by Velpeau,* Dunn,† and others.

THOMAS KING HORNIDGE.

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* *Méd. opér.* 2nd ed. t. ii. p. 599.
† *Med.-Chir. Trans.* vol. xii. p. 167.

DISLOCATIONS.

THE term 'dislocation' is etymologically equivalent merely to 'displacement;' but in surgery the use of the word has been restricted to the displacement of one articular surface of bone from another;* and it would perhaps be more convenient still further to narrow the meaning of the term, so that it should include only such of these displacements as are caused by violence. This restriction, however, has not yet been made; hence dislocations are divided into three classes—congenital, pathological, and traumatic. The first are malformations, which, if they are to be treated at all, must be attacked in early life. Their consideration is therefore deferred to the section on the SURGERY OF CHILDHOOD. The second are symptomatic of various diseases of the joints, in which the displacement of the articular surfaces, though of the highest practical importance, is pathologically non-essential. They will be found discussed in the essay on DISEASES OF THE JOINTS. The third only form our present subject.

A traumatic dislocation, then, is a forcible separation of the articular surfaces of two or more bones. This is effected by the rupture or stretching of their ligaments, and may be *partial*, i.e. when parts of the articular surfaces remain in contact with one another, though not the parts naturally opposed; or *complete*, when the surfaces are not in contact by any part. Another classification of dislocations which it is necessary to dwell upon is, into *simple*, in which the dislocated bone is not exposed to the air; and *compound*, where there is a wound communicating with the injured joint.

The various special dislocations, e.g. of the hip, shoulder, &c., are described further on, with the injuries of the regions in which they severally occur; it is, therefore, only necessary here to state the general principles applicable to the pathology and treatment of Traumatic Dislocation.* Complete dislocations will be first spoken of, as affording the most intelligible and perfect examples of the injury; and the consideration of compound dislocations will be reserved till the principles which guide surgeons in the treatment of the simple injury have been described.

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* Occasionally, it is true, the term 'dislocation' is applied to the displacement of soft parts. Thus we talk of 'dislocation of the crystalline lens,' 'dislocation of the testicle into the perineum,' 'dislocations of tendons from their grooves,' &c. This use of the word, however, can hardly create ambiguity.

Causes.—The causes of dislocation, as of fracture, are twofold; external violence, and muscular action. The latter, however, is, in the healthy state of parts, very rarely the cause of dislocation, while (as above shown, p. 37) fractures from this cause are less uncommon. Many instances, however, have been put on record, in which the humerus has been dislocated by the action of the muscles only; and of this accident the present writer saw once an example in the case of a patient who was lying in bed on account of another injury. In making some sudden movement of his right arm, the precise nature of which he could not afterwards explain, the humerus slipped out of the socket. No difficulty was experienced in reducing it. In this patient the bone had never been dislocated before; but in cases of old dislocation, especially when the original treatment has not been sufficiently prolonged, the injury is very often reproduced by mere muscular action, and then the bone is just as easily reduced. Many persons in whom the shoulder is so affected, have learnt to reduce the dislocation for themselves, by reaching over a gate, taking hold of one of the lower bars, and hanging in this position, when the mere weight of the body is sufficient to restore the parts to their place. There is one dislocation which is almost always produced by muscular action, that of the lower jaw, and the dislocation of the patella is very commonly so caused.

Much has been said by systematic writers about the share which the muscles take in the production of the common dislocations from external violence, e. g. those of the hip and shoulder. There is, however, little practical importance in the question, though it is interesting physiologically, from its application to animal mechanics. It is not probable that the muscles have any other influence in producing most dislocations than that they sometimes fix the bone on which they act in positions in which the external force acts advantageously upon it. But since, as M. Malgaigne observes, most dislocations can be produced in the dead body as easily as in the living, it is clear that the action of muscles is a very unimportant element in such accidents.

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* For the sake of simplicity and to avoid repetition, the word 'traumatic' will be dropped in the sequel; but all that follows must be understood as spoken only of that form of dislocation.

A less doubtful effect of muscular action is the change which is often produced in the position of the displaced bone during the first few days after the accident; so that a bone which has been thrown into a certain position at the time of the injury may afterwards be found in another place. Thus the head of the femur is often drawn from the dorsum ilii into the sciatic notch; and the reverse of this sometimes occurs. Such dislocations are sometimes called consecutive. The action of the muscles is aided perhaps, in some cases, by the weight of the limb.

Symptoms.—A complete dislocation is, in typical cases, attended with such very distinct symptoms, that when these are fairly detailed upon paper the reader is tempted to say that the injury is unmistakable. Yet the great number of old unreduced dislocations which are still seen, even in patients who have been from the first under medical supervision, proves that, notwithstanding the elaborate care with which the symptoms of dislocation in general, and of each special injury in particular, have been described ever since the time of Astley Cooper, such mistakes cannot always be avoided, even by well-informed and careful men; and it is no doubt true that errors in diagnosis on this head will sometimes occur to the best surgeons, in consequence of extreme depth of the parts, of great effusion and swelling over them, or of complication with other injuries; but with proper care such mistakes ought to be very seldom made even at the time of the accident, and attention to the subsequent progress of the case will always enable the surgeon to correct his error while there is yet a fair prospect of easy reduction.

The general symptoms of dislocation are, sudden loss of motion, following an injury which (except when the joint has been formerly the seat of a similar lesion) is usually severe; loss of the natural shape of the parts, from changes in the relations of the muscles surrounding the joint, and the altered position of the bones; change in the length of the limb, which in the great majority of dislocations is shortened; loss of the power of voluntary motion, except to a limited extent and in certain directions; absence of crepitus when the limb is manipulated; and great interference with passive motion, especially to certain movements; while, on the other hand, other passive movements limited or impossible in the healthy body may be absolutely unimpeded, in consequence of the rupture of the ligaments which before restrained them. Other symptoms, accompanying peculiar dislocations, and depending on interference with the functions of viscera, nerves, or vessels pressed upon or lacerated by the displaced bone, may be present and may assist in diagnosis; but they need not be further alluded to in this place.

Crepitus is sometimes met with in dislocation, and that from three causes: 1. The ordinary pseudo-crepitus is a crackling sensation, due to the presence of fluid in the joint-cavity, the sheaths of the tendons, or neighbouring spaces, easily distinguished from true bony crepitus. This is comparatively often met with some time after the accident. 2. True bony crepitus may be perceived at any time, if the displaced head of the bone rests on a fractured process in the neighbourhood, as in a case reported by the present writer, in *Med.-Chir. Trans.*, vol. xli., where the head of the humerus rested against the stump of a fractured coracoid process. 3. Finally, there are a few cases in which, as it appears, the soft parts separating the displaced head from the surface of bone on which it rests have become absorbed, and these surfaces of bone roughened by inflammation crepitate harshly when rubbed together. This cannot occur till some days after the accident, at the earliest.

Pathological anatomy.—In a complete dislocation, the injury is not confined to the bones and ligaments only, but involves more or less lesion of the surrounding parts. The articular capsule is usually widely lacerated, and the special ligaments of the joint torn in various degrees. In partial dislocation it seems probable that this feature may be absent, the capsular and other ligaments being merely put on the stretch; but it must be confessed that our knowledge of these injuries is not as yet very perfect. Mr. Wormald has related a case* where a partial dislocation of the hip, with fracture of the acetabulum, appears to have been the original accident, and where the ligamentum teres remained untorn; and Mr. Soden's case of (supposed) partial dislocation of the humerus upwards from displacement of the long head of the biceps is well known;† but, from the length of time which has passed in most of these cases between the injury and death, it is impossible to form from them an opinion as to the usual condition of parts at the time of the accident. Even in cases of complete dislocation, however, we may admit the possibility of simple stretching of the capsular ligament, without rupture, though perhaps we might not be able to refer to any preparation or history which proves this beyond doubt. There is a preparation (No. 868) in the Museum of the College of Surgeons, showing the dissection, by John Hunter, of a shoulder-joint three weeks after reduction of a dislocation, in which he believed that the capsular ligament had not been torn, but merely stretched or bruised. There was, however, some trace of injury to the membrane still perceptible; and it must be allowed to be possible that it might have been lacerated at the time of the accident, and afterwards have united. The case of dislocation of the bones of the foot from the astragalus, reported by Mr. Pollock,* shows the extent to which ligaments may be stretched without absolute rupture. The os calcis was so movable on the astragalus that the sole of the foot could be turned vertically inwards; yet the interosseous ligament, though stretched, was not completely ruptured.

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* *Medical Gazette*, vol. xix.

† *Med.-Chir. Trans.* vol. xxiv. p. 212.

Besides the injury to ligaments, a variable amount of damage is frequently done to the surrounding muscles, which are torn away from their attachments, lacerated, or stretched, according to the nature and extent of the displacement. The great nerves in the neighbourhood (such as the circumflex in the shoulder) are often compressed or lacerated, and hence severe pain at the time of the accident, and paralysis afterwards of the parts supplied by those nerves, which is sometimes irremediable. The large vessels almost always, in simple dislocation, escape without injury;† but they are sometimes compressed by the displaced bone, so as to obstruct the circulation through the limb. Fracture of some of the processes surrounding the joint is a very common complication. In fact, in some joints (as the ankle) it is rare to find a pure specimen of dislocation. The only importance of this fact is, that in such cases more care should be taken to procure and maintain exact apposition.

Such are the immediate effects of a dislocation. If the bones be restored to their natural position, all these injuries are generally soon repaired. The ruptured capsule readily heals, the injured muscles and tendons regain, in a great measure, if not entirely, their former condition and their former strength, and even the nerves, if contused or lacerated, may slowly recover themselves. It may, indeed, happen, although it is not common, that the joint inflames after reduction, even under proper and judicious treatment; but this complication need not be further dwelt on here, since it must be treated on the same principles as any other case of articular inflammation after injury.

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* *Med.-Chir. Trans.* vol. xlii. p. 43.

† A case was operated upon by Professor Goldsmith, of Louisville, in which the femur had been dislocated on to the brim of the pelvis, so as to lie under the femoral artery. It remained unreduced for two months, when a diffused aneurism was found to have been formed. The common iliac artery was tied. The patient died on the fifth day. The femoral and external iliac arteries were found perforated to the extent of an inch on the posterior external aspect; and the head of the femur lay in the cavity of the aneurism. (*American Journal of the Medical Sciences,* July 1860, p. 30.) In dislocations of the shoulder also the axillary vessels are occasionally injured.

If the dislocation, on the contrary, has been neglected, or if it has been found necessary to abandon its treatment, further changes necessarily follow. These changes, like almost all other morbid phenomena, are principally efforts after the repair of the injury. The chief of them all is the formation of a *new joint*. The head of the dislocated bone forms for itself a cavity on the bone upon which it is thrown; a cavity which is caused partly perhaps by inflammatory softening and the removal of some of the original bone, but principally by deposit of new bone on the surface of the latter. These new cavities are found lined by a substance which to the naked eye closely resembles cartilage, but which, under the microscope, shows the structure of fibrous tissue. The original articular cavity at the same time gets filled up with a fibroid deposit, and the head of the bone is surrounded in its new position by a cyst or new articular capsule formed from the surrounding areolar tissue. At the same time the displaced bone may suffer various changes of form, from inflammatory softening and ulceration, by which its shape and size will be essentially altered. These observations apply almost entirely to joints resembling the ball and socket in which an articular head is dislocated on to a flat bone. In ginglymoid and arthrodial articulations the process of repair will be much less extensive, and therefore the resulting recovery of motion much less perfect. Sometimes, indeed, in small joints of this kind, such as those of the fingers, complete bony anchylosis may follow.*

The consequences of an unreduced dislocation, however, are not limited to the bones which are displaced, since the altered position of the soft parts and the irritation set up, somewhat in the manner of a foreign body, by the displaced bone, materially impede the function of the muscles. The tendons may have been carried away from their points of attachment and united to some point which is partially or entirely immovable; or (as is often the case with the long tendon of the biceps) they may have been split longitudinally and thereby much weakened, although a part retains its natural connections. As a consequence of these injuries, and of the inflammation which follows them, adventitious formation of bone is sometimes found in the tendons and in the other fibrous structures around the joint; another particular in which the consequences of old dislocation resemble those of chronic rheumatic arthritis, and therefore a fresh difficulty in the diagnosis of the two affections.*

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* Preparations showing this condition may be found in the Museum of St. Bartholomew's Hospital, Series III. Nos. 57, 61.

Various causes may combine to produce adhesion between the bones. The articular cartilages will in all probability be absorbed, either as a consequence of inflammation (e.g. when the head of the bone has been resting against a prominent process or the stump of a fracture),† or from the atrophy which removes parts whose function is lost. The very completeness of the reparative process may sometimes be the cause of permanent loss of function to the joint. Thus in a case of unreduced dislocation of the radius, preserved by the writer in the Museum of St. George's Hospital, the orbicular ligament is seen to have been carried away with the head of the radius, and is firmly united in this position by both its ends to the humerus as well as to the radius, thereby binding these bones firmly together, and entirely preventing rotation. The great tendons sometimes form bands of adhesion between the bones. This is again illustrated by a specimen of dislocated elbow in the same Museum, where the brachialis anticus, torn off the coronoid process, which is carried into the olecranon fossa, has become firmly united, both to the trochlear surface of the humerus, and to the ulna below its original attachment, so as to form a kind of soft anchylosis between them.

It seems probable that in some cases the edges of the rent in the articular capsule may unite either partially or completely, so that the hole which admitted the passage of the bone out of the joint will no longer allow it to go back again.‡ Professor

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* Specimens in which a deposit of new bone in tendons is believed to have followed dislocation may be found in the Museum of Guy's Hospital, Nos. 1297^{50}, 1298^{50}.

† *Med.-Chir. Trans.* vol. xli. p. 450.

‡ See a case related by Mr. Hilton, *Guy's Hospital Reports*, Ser. ii. vol. v.

Fabbri believes that the head of the bone which has been dislocated may be prevented by the laceration of the capsule being somewhat too little, or by the interposition of other soft parts, from returning entirely into the articular cavity when reduction is first attempted, and that thus a dislocation originally complete may become incomplete.*

It is also noticed by Professor Hamilton† that the great vessels sometimes become adherent to the capsule or periosteum of the displaced bone, leading to the risk of fatal hæmorrhage should forcible attempts be made to effect reduction.

Such are the principal effects of unreduced dislocation. Other pathological changes may doubtless be observed; but the scope of the present work does not admit of detailed notice of mere pathological curiosities, and the reader who desires to follow the subject more minutely must consult special treatises. The chief importance of the study of these changes is in order to know the time at which they occur, so that the justifiability or otherwise of attempts at reduction a given time after the accident may be determined. Alteration in the shape of the bones, either by widening of the articular cavity or absorption of the head of the bone, may render permanent and safe reduction hopeless;‡ or deposit of new bone on the dislocated head may render it too large to fit the cavity; or the presence of soft anchylosis between the bones (either as a consequence of inflammation or of the vicious union of ruptured ligaments or tendons) may render necessary for reduction a force greater than can safely be applied; or the original articular cavity may be filled up with lymph or with the remains of the old capsule; or the articular cartilages may have been absorbed, so that no healthy joint could be reproduced.§

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p. 96; a preparation in the Museum of St. Bartholomew's Hospital, dissected three weeks after the accident (Ser. III. No. 20); also a case by Hamilton of the United States, *American Journal of the Medical Sciences*, Nov. 1837, p. 47 (quoted by Malgaigne, op. cit. p. 53); and a case by Hamilton of Dublin, presented to the Dublin Pathological Society, Nov. 28, 1868. In the latter case, however, there was some fracture of the articular cavity.

* *Memorie della Società Med.-Chir. di Bologna*, vol. ii. p. 629.

† *On Fractures and Dislocations*, Philadelphia, 1860, p. 492.

‡ Mr. Curling relates a case in *Med.-Chir. Trans.* vol. xx. p. 338, in which insecurity of reduction was occasioned by absorption of the glenoid cavity.

§ The deposit of bone in the tendons probably does not take place till a time at which no prudent surgeon would think of endeavouring to reduce the dislocation.

So that, in determining the question of the justifiability of attempts at late reduction, it is material to know the period at which these changes occur. Unfortunately nothing is more difficult, since patients are not often kept under observation so long after the accident, and therefore the history of the case is rarely known. Most of the preparations in our museums are quite devoid of histories, and the greater part of them show the state of things at a time when all question of treatment must have long been abandoned. It is clear, however, that the formation of a false joint goes on in some cases with considerable rapidity. Thus in Mr. Hilton's case previously mentioned (p. 105, note), the patient died of another disease thirteen weeks after the accident; the only reduction possible still left the head of the bone external to the capsular ligament. Mr. Hilton says: 'All these parts (viz. the head of the humerus; the remains of the original capsule, now interposed between it and the glenoid cavity; the fractured great tuberosity, and its attached muscles) were included by a thin new fibro-cellular capsular ligament, and the surfaces contributing to the formation of the new joint were all smooth, and covered, as it were, by a new adventitious synovial membrane.' In M. Malgaigne's work* a case is cited in which similar changes were discovered eighteen days only after the accident. Several other interesting cases will be found in the same work; but the cases hitherto published are far too few to form a scientific foundation for any general conclusions. And, on the other hand, several cases have been put on record in which dislocations have been successfully and permanently reduced at a time much beyond that which is laid down in most of our standard works. Thus, even before the introduction of chloroform, M. Sédillot succeeded in reducing a dislocation of the shoulder backwards more than a year after the injury.† Dieffenbach is said to have reduced a dislocation of the shoulder two years after the accident, Breschet one of the hip on the seventy-eighth day; and Mr. Brodhurst relates two cases, in one of which he succeeded in reducing a dislocation of the shoulder on the one hundred and seventy-fifth day, and in the other a dislocation of the wrist, six years after the accident.‡

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* Op. cit. p. 52.

† *Contributions à la Chirurgie*, vol. i. p. 132.

‡ 'On the Reduction of Old Dislocations,' *St. George's Hospital Reports*, vol. iii. p. 68.

Diagnosis.—On the subject of diagnosis hardly anything need be said in this place. The only injuries with which dislocation can be confounded are, (1) simple contusions and sprains, and (2) fractures near the joint, or separation of epiphyses. The diagnosis in the first case is made by recognising the positive symptoms of a dislocation instead of the negative symptoms which imply its absence; and as to the second, the diagnosis between fracture and dislocation has been already discussed (see FRACTURES, p. 49). Separations of epiphyses are distinguished from dislocation by the following characters: 1. The former can only occur at ages at which the epiphyses are separate from their shafts; the latter at any age. 2. The former are, as a rule, easy to reduce, and difficult to retain; in the latter, as a rule, these conditions are reversed. 3. In the former, the points of bone immediately surrounding the joint preserve their normal relations; in the latter, these relations are variously altered. 4. The sensation perceived in the two injuries is different, for separation of an epiphysis is usually complicated with fracture, and therefore crepitus can be elicited. Perhaps it may be added, that an error in diagnosis would be rather mortifying to the surgeon than prejudicial to the patient, since the general indications are the same.

Treatment.—When the diagnosis has been established, if the injury is recent and the patient is suffering much pain, reduction should be at once attempted—at least, this should be the rule in all joints except the hip, where it is perhaps better to wait until chloroform and some extending apparatus can be procured, in case either the one or the other should prove necessary; and in some of the smaller joints, when the patient does not suffer much, we may be guided by circumstances whether to attempt reduction immediately or put it off till some more convenient time and place. There is always a fair chance of reducing a recent dislocation, without any appliances or assistance; although, from peculiar complications, or from the great muscularity of the patient, failure may occur in almost any. The principles of reduction are very simple, and the various mathematical and anatomical refinements, with which the ingenuity of systematic writers has surrounded the subject, are never thought of in practice. The process is as follows: 1. The upper end of the limb must be fixed; 2. The lower end must be pulled in the most advantageous direction (reference being had to the insertion of muscles into it, and to the shape of the parts on which the displaced head is lying), until by this extension the limb has been restored to its proper length; and then, 3. The displaced bone or bones must be directed into the joint by manipulation or traction.

The second is the most difficult indication to fulfil. In the majority of recent and simple dislocations, all that is necessary is to know the anatomy of the parts, and the rules applicable to the special injury under treatment, which will be found in subsequent sections of this work, and to make manual extension in the manner indicated by those rules. But in more complicated and less recent cases something must be done to relax or subdue the muscles. It was formerly considered necessary for this purpose to reduce the powers of the system by venesection and tartar-emetic; but this treatment has now been entirely superseded by the discovery of chloroform. In no part of operative surgery has this great discovery made a more complete revolution than in the treatment of dislocation; so that what was frequently a most difficult, and always a very painful operation, has now become comparatively painless, and usually quite easy. The rule, therefore, in all dislocations which cannot be reduced by the first attempts which the surgeon makes with his own unaided force, is to administer chloroform; having the necessary apparatus at hand for making forcible extension, if required. The only exceptions to this rule are, when, from concomitant disease or injury, chloroform is in the judgment of the surgeon contra-indicated. But these reasons act also to contra-indicate all forcible attempts at reduction; for should the contra-indication be a diseased state of the heart,* this condition would also forbid a forcible, prolonged, agitating, and painful operation; and if the complication of other injuries renders it unadvisable to give chloroform, no objection exists to waiting until the effects of such injuries subside before attempting reduction.

In old times, the muscles used to be overcome by the prolonged traction of a number of men, or by various mechanical contrivances, some of them of the most ludicrous nature, which may be seen described in old books of surgery. For these paraphernalia a later age has substituted the *pulleys*, a most valuable

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* The reader will observe, that no opinion is here expressed on the correctness of the opinion that disease (whether valvular or degenerative) of the heart is an absolute contra-indication to the employment of anæsthetics.

machine, and one still indispensable to the treatment of dislocation, though less frequently called into play since the discovery of chloroform than it used to be.* It consists of a system of pulleys on a single string; an arrangement by which the force is multiplied by the number of the strings on the lower block. The pulleys are attached on one side to a staple driven into the wall, and on the other to a bandage of leather firmly bound to the limb, and usually to that segment of it which is dislocated, instead of to the one below, e.g. above the elbow in a dislocation of the shoulder rather than below. The limb above the dislocation is fixed, by means of another stout leather bandage, to a staple opposite the former. Having seen that the string of the pulleys runs freely, and that the bandages are all in their proper places, the surgeon confides to one assistant (if he have two) the care of the upper bandage, to see that the patient's body does not get dragged out of place by the force which is to be applied, and to the other the string of the pulleys. This string, having been made so tight that the upper bandage is visibly pulled upon, is then to be cautiously and gradually tightened, a small piece being pulled in at regular intervals. In France, an instrument called the dynamometer is attached to the pulleys, in order that the precise force used may be accurately measured. Meanwhile the surgeon manipulates the head of the bone; and when it appears to him that the force has acted sufficiently upon it, i.e. when it has come opposite to the empty articular cavity, he gives the word to his assistant to drop the string of the pulleys; and then, without the loss of any time, directs the head of the bone into the articulation, either with his hands or with a lever of some kind passed below it. Should this attempt fail, it may be renewed, or the limb may be bandaged in the position which it has now assumed, and a fresh trial made on the next or some early day. It is frequently advisable in old dislocations, where the displaced bone has contracted adhesions, to limit the first extension to breaking down these bands, postponing all efforts at complete reduction till another opportunity. Reduction having been accomplished, the position of the joint must be maintained by bandages, or slings, for a certain period, which varies for each joint, and which is prescribed for each in subsequent sections. If this precaution is omitted, the head of the bone will almost certainly slip out of the lacerated opening in its articular capsule, and the dislocation be reproduced; or even where this does not take place, the motion of the joint will cause some amount of effusion, which will interfere with the proper union of its ligaments, and leave the joint permanently weak, and very liable to consecutive dislocation. Cases of this kind are very frequently seen, in which dislocation is reproduced by very trifling causes, and is as easily reduced, showing the laxity and weakness of all the parts surrounding the articulation. Hence it is important to keep the parts at rest during a sufficient time, though the opposite extreme must also be avoided, for too protracted inaction might cause troublesome or even permanent loss of motion from soft anchylosis.

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* Cases will occur when the pulleys are not at hand, and then the assistance of several men, to make extension and counter-extension, must be employed. Great care should be taken to make them pull together gradually and steadily. Or the following contrivance, described by Dr. Gilbert of Philadelphia (v. *Hamilton*, op. cit. p. 494), may be used. 'Place the patient, and adjust the extending and counter-extending bands as for the pulleys; then procure an ordinary bed-cord or a wash-line; tie the ends together and again double it upon itself, pass it through the extending tapes or towels, doubling the whole once more; and fasten the distal end, consisting of four loops of rope, to a window-sill, door-sill, or staple, so that the cords are drawn moderately tight; finally, pass a stick through the centre of the double rope, then by revolving the stick as an axis, or double lever, the power is produced precisely as it should be in such cases, viz. slowly, steadily, and continuously.'

Other instruments have been proposed for making forcible extension, such as Jarvis's adjuster, Bloxham's dislocation tourniquet, &c.; but it has never occurred to me to see any case in which all the force that could be prudently applied to the limb was not easily obtained by the pulleys.

When reduction fails from any cause, much judgment and care are required to determine whether the attempt should be renewed or abandoned. On the one hand, the damage and discredit of leaving the patient to his fate will weigh powerfully in favour of perseverance; on the other, serious mischief has often resulted from too protracted and too violent attempts at reduction. Bones have been fractured, tendons ruptured, even the large vessels of a limb have been torn.* Still more frequently the pressure of the bandages produces troublesome sloughing, which, when the limb is of small size, as the thumb, may even cause the loss of all its remaining usefulness.† The method of procedure which was adopted should be carefully reviewed, in order to see whether there was any fault in it; in which case there will be much encouragement for the trial of a better plan. If, however, no improvement can be suggested in this respect, then attention must be directed to the position of the limb, whether changed or not by the extension; to the nature of the dislocation; the state of the parts; and to the time which has elapsed since the accident. If the position of the displaced bone has been, though not entirely remedied yet improved; if no injury has been done by the extension; if the dislocation is within a period at which reduction is commonly successful, and of a joint which offers no peculiar obstacles—then the decision will be in favour of persevering; while in the opposite case the surgeon will probably require the expressed wish of his patient (if a person of intelligence and with a full understanding of the question), and the assent of competent colleagues, before venturing on a step which involves certain risk, and offers only doubtful advantage.

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* A paper by Mr. Callender in vol. ii. of the *St. Bartholomew's Hospital Reports* may be referred to as giving a very interesting account of the cases in which rupture of the axillary vessels has been known to occur in the reduction of a dislocation. This accident is rare, occurs almost always in elderly persons, and has affected the artery in every recorded case except one, in which the vein alone was torn (Price's case, loc. cit. p. 108).

† Samuel Cooper (*First Lines of Surgery*, 7th ed. p. 705) gives the surgeons

If it be found necessary to abandon a case of dislocation, the patient may be comforted with the assurance that his limb, though it will never be as useful as before, may yet recover a good deal of motion; at least, this assurance may be given very confidently in the case of such joints as the hip and shoulder. The ultimate result of such cases is, that the displaced bone forms for itself a new socket, in which a considerable amount of motion is allowed. The result in ginglymoid joints is usually less favourable; still, they may do well if passive motion be kept up.

Partial dislocation.—The previous observations refer to complete dislocations. It remains that something be said about partial dislocation. This injury is rarely met with in the large enarthrodial joints; whether because it really only occurs thus rarely, or whether in part from the difficulty of diagnosis, may be a question; but the rarity of undoubted specimens to be found in our great museums, and still more the rarity of dissections

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of St. George's Hospital, fifty years before his day, the credit of having *pulled off* a man's thumb in vain attempts to reduce a dislocation. I cannot find on what authority this story rests; but gangrene has no doubt often followed such attempts. A case was lately published in France in which the forearm of an old woman was torn off at the elbow in attempting to reduce a dislocation of the shoulder. *Gazette Hebd.,* 1864, p. 299.

of these injuries soon after the occurrence of the accident, leave little doubt that the lesion is not common. It need hardly be said, at the present day, that the great majority of the specimens which used to be described as 'partial dislocation' are really instances of displacement from disease.

The symptoms of partial would be the same as those of complete dislocation, only less strongly marked, viz. sudden loss of motion, change of shape (independent of other concomitant injuries), and change in direction of the axis of the limb. But it will be at once allowed, by anyone who has seen much of surgical practice, how difficult it is to distinguish these symptoms in the case of a deeply-seated joint from the effects of severe contusion or impacted fracture; and hence in such joints the diagnosis must remain rather uncertain. In some articulations, however, such as the knee, where the bones are in contact by very wide surfaces, any dislocation which occurs is almost necessarily partial, and here the diagnosis can generally be easily made.

The treatment must be regulated by general principles, even if the diagnosis remain somewhat doubtful. The limb must be manipulated, under chloroform if necessary, until its axis is natural and its length corresponds with the other, and it is, if possible, restored to free passive motion; and it must be then confined to this position for as long a period as may be judged necessary.

The progress of the case will generally afford valuable information as to the presence or absence of fracture; since if the ligaments merely be ruptured, and the bones partially displaced, sufficient solidity is very soon obtained to restore at least some extent of motion; while in fracture the limb continues for a long period quite as helpless as on the first receipt of the injury; for the uniting medium even in the smallest bones does not acquire sufficient solidity to allow of voluntary motion for at least a fortnight; and a much longer period is required in the large bones of the limbs, which are the usual subjects of such an accident as is here spoken of. Ecchymoses also appear, *cæteris paribus*, to be more extensive and persistent in fractures than in other injuries.*

Compound dislocation is an accident rarely met with uncomplicated, except in the ankle-joint, or some of the articulations of the fingers, as the metacarpo-phalangeal joint of the thumb. Rules for the treatment of each special accident, deduced from experience, will be found in other parts of this work. The general considerations which should guide us in treating these injuries appear to be:

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* Packard's *Malgaigne*, pp. 84, 418.

1. That the injury does not of itself call for amputation, unless perhaps in the knee, and here only in adult life.

2. That if the head of the bone protrudes from the wound, it is better to remove it than to make any violent efforts at reduction.

3. That it is always better to excise the end or ends of the bones when the joint is one in which anchylosis is specially to be deprecated.

4. That in the joints of the lower extremity no bone should be removed unless absolutely necessary, and every attempt made, by enforcing strict rest and confined position, to induce anchylosis.

The prognosis of compound dislocations of large joints is highly unfavourable; and in any joint anchylosis will most probably ensue, though in the fingers it may sometimes be obviated by timely passive motion.

T. HOLMES.

GUN-SHOT WOUNDS.

GUN-SHOT wounds consist of injuries from missiles projected by the force of explosion. As the name implies, this class of wounds is ordinarily restricted to injuries resulting from fire-arms; but it should be remembered, that wounds possessing the same leading characteristics may result from objects impelled by any sudden expansive force of sufficient violence. The fragments of closed vessels burst asunder by the elastic power of steam, will inflict wounds of precisely the same nature as those caused by the bursting of a shell. Injuries from stones in the process of blasting rocks offer familiar examples of wounds of a like nature. In the following pages, however, gun-shot wounds will be considered as they are met with in the operations of warfare.

HISTORY.

From the earliest time of the application of gunpowder to implements of war, down to the present day, the wounds inflicted by its means have excited the most marked interest among surgeons; nor can this be wondered at, when the immensely superior energy of this agent in comparison with all the mechanical powers previously in use for hostile purposes, and the terrible nature of its effects on the human frame, are remembered. By its introduction the whole aspect of war was changed, in a great degree, by the distance at which opposing forces were enabled to contend with each other; just as, in our day, the nature of battle is undergoing another change from the increased range and precision of fire obtained through the general use of rifled weapons. But though the alterations now being made in the qualities of fire-arms are of the utmost importance to those whose business and especial study is the art of war, to the army surgeon the interest they excite is chiefly limited to the degree of injury and destruction inflicted by them as compared with weapons of a less perfect kind; while, to the surgeons employed at the time of the introduction of gunpowder, the wounds were wholly new in their nature as well as degree. Recollecting the ignorance which then prevailed in all departments of science and art, it can excite no surprise that the new engines of war, with the flame and noise accompanying their discharge, were regarded with superstitious terror; nor that surgeons for a long time found an explanation of the sloughing severity of the injuries they inflicted, and of their difficult cure, in the poisonous nature of gunpowder, or in the burning effects of the projectiles from heat acquired in their rapid flight through the air. Unfortunately, these erroneous views did not end with the theories from which they started, but led to treatment which only aggravated the evils inflicted by the new weapons, and interrupted the progress of the healing action which nature would otherwise have established. The wound being regarded as a poisoned wound, it was believed that the poison could only be got rid of by a long and tedious process of local suppuration, and so prevented from entering the system of the patient. The irritative fever, the wasting and emaciation, and all the other results of the protracted cure of the injury, were pointed to as so many evidences of the indirect effect of the poison working in the frame; just as the constitutional shock at the time of the wound, the loss of vitality along the surface in the track of a small projectile, or of the tissues laid bare by the passage of the cannon-ball, were regarded as evidences of its direct influence. On looking back at the works of successive writers on this class of injuries, the reader is surprised that the improvement in their treatment has been so gradual and slow; and cannot fail to observe that the chief impediment to a more rapid amelioration of the system pursued has been the prevailing idea of the necessity of delaying the tendency of nature to close the wound, in order that the supposed poison might be eliminated from the constitution. The openings of entrance and exit and track of the ball were incised; the wound dilated by tents or other means, and terebinthinates, or even boiling oil, poured into it; irritating compounds and ointments applied where superficial dressings were practicable; and it was only after the wound was considered to be fully purged of its venom and foul humours by the extensive suppurative action thus kept up, that cicatrisation was permitted to be established.

It required long years of observation in many conflicts, and the exercise of much industry, not to mention moral courage in opposing authorised custom and prejudice, before a simpler and more rational mode of practice was followed. It is satisfactory to know, that though continental surgeons have written more voluminously on the subject of gun-shot wounds, the older English military surgeons and writers stand forth conspicuously in leading the way to a more practical knowledge of their nature and proper treatment.

Although, however, much that was erroneous was removed by the earlier surgeons, the light of science can hardly be said to have penetrated this important province of military surgery until the great and last work of John Hunter, on the *Blood, Inflammation, and Gun-shot Wounds*, was published in 1794. This distinguished philosopher served as a surgeon on the Staff of the army in the expedition against Belleisle in 1760, and in the same capacity in Portugal in 1763. He subsequently filled some of the highest positions in the medical department of the British service: having been appointed in 1776 Surgeon Extraordinary to the Army, in 1786 Deputy Surgeon-General, and in 1791 Surgeon-General—a laborious office, corresponding with that of the Director-General, under existing arrangements.* The physiological principles which John Hunter enunciated, based on extensive study and observation in civil life, cannot be controverted; but their practical application, so far as regards the treatment of gun-shot wounds, has been greatly modified since his treatise on the subject was published. There cannot be a better illustration of the special position in which this department of military surgery is placed, from the peculiar circumstances under which it is practised, than the fact, that though men of the highest mental attainments have discussed the subject of gun-shot wounds, we are nevertheless indebted to practical experience in military campaigns for every improvement, some few of recent date excepted, that has occurred in their treatment. Thus, John Hunter was led to advocate very strongly the delay of amputation, after severe gun-shot wounds, for weeks, that the patient's constitution might accommodate itself to the injury; while more extended observation has demonstrated that such secondary amputations are more fatal than those which are performed shortly after the infliction of the wounds leading to them—the advantage of the patient thus coinciding with what must very constantly happen to be a practice of necessity in the field. Mr. Guthrie remarks, in his *Commentaries on the Surgery of the Peninsular War between* 1808 *and* 1815, that the surgical principles and the practice which prevailed at the commencement of the war were superseded on almost all important points at its conclusion; and he quotes a remark of Sir Astley Cooper, to the effect, that the art of surgery received from the practical experience of that war an impulse and improvement unknown to it before.

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* John Hunter held this office during the early part of the war with France which preceded the peace of Amiens. After Hunter's death the direction ceased to be vested in an individual, and, instead, an Army Medical Board was constituted, consisting of a Physician-General, Surgeon-General, and Inspector-General of Hospitals.

The still more recent military operations in Algeria, in Schleswig-Holstein, in the Crimea, and in India, have afforded the opportunity of testing practically the applicability to army practice of some of the great improvements which have been accomplished in the civil practice of surgery in Europe since the termination of the war in 1815. Among these may be particularly enumerated, the avoidance of amputation of limbs by recourse to excision of joints; resections of injured portions of the shafts of long bones; mitigated amputations, by removal only of those terminal portions of the extremities which had been destroyed by the original injury; and the practice generally, of what has been styled conservative surgery. In these wars, too, the value of chloroform as an anæsthetic agent in military surgery has been fully established. They have also especially illustrated the influence of various states of health and climates on the results of gun-shot wounds. All the anticipations which were held out at the commencement of some of these campaigns have not been realised, but still they have added much valuable information and many improvements to military surgery.

The alterations made during late years in the arms of the greater proportion of the troops of the leading Powers of Europe, namely, the transformation of muskets into '*armes de précision*,' with rifled barrels and graduated aims, have led to changes in the severity and almost in the nature of gun-shot wounds from small balls; and the results of these changes require the especial attention of army surgeons. The effects of the new rifle-balls were widely witnessed during a portion of the period of the Crimean war. They were seen in still greater proportion during the campaign of 1859 in Italy, and additional practical observations have been published by the continental surgeons engaged in it. The fearful numbers of killed and wounded, greater than in any former experience, owing to the large masses of troops brought into collision with each other, exhibited the effects not only of rifled muskets, but of rifled cannon also; and, in the French forces engaged, an opportunity was afforded of instituting a comparison of the results of their treatment under circumstances of bodily health, and hospital accommodation very different from those of the French army in the Crimea.

The war of the rebellion in the United States has again largely added to our experience in gun-shot wounds from rifled weapons. In England, one valuable result which emanated from the war with Russia was, the regular collection and arrangement under Government authority, for the first time, of the observations and practice of the medical officers employed in the campaign.* The Government of the United States has followed the same course. An official department, thoroughly and very extensively organised, under the direction of the Surgeon-General, is now carefully arranging full reports, both statistical and professional, on the injuries of the war and their results. Specimens to illustrate the pathology of wounds were collected while the war was in progress, and a large museum illustrative of military surgery in all its branches now exists at Washington.

During the year 1864, we had nearer home the war carried on in Schleswig and Holstein, and during 1866 the short but decisive war between Prussia and Austria. In the former war, for the first time, all the troops were armed without exception with rifled weapons. In the recent campaign in Germany the effects of breech-loading arms were witnessed, and since that date the change of muzzle-loaders into breech-loaders has either been made or is being made in all the armies of Europe. The rapid and uninterrupted fire that can be kept up by breech-loaders, and consequently their influence on the *number* of wounds produced within given limits of time, will probably be found to be the chief points of interest to military surgeons: it does not appear likely that the characters or any of the particular features of the wounds themselves will be influenced by the change.

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* The French statistics of the Crimean war have now been completed by the admirable work of Dr. Chenu (*Rapport sur les résultats du service médico-chirurgical aux ambulances de la Crimée, par J. C. Chenu*, &c., pp. 732, 4to; Paris, 1865); and there is every reason to expect even still more accurate information regarding the results of the Italian campaign of 1859, and the French campaigns in Mexico and Cochin China before long, from the labours of the same indefatigable statist. It is hoped that equally correct information will in a short time be available respecting the Prussian campaign of 1866.

One result of the system of breech-loading is, that it enables detonating and explosive bullets to be discharged from small fire-arms without danger to the marksmen handling the weapons. Dr Scrive, in his *History of the Eastern Campaign*, states that explosive bullets were employed by the Russians in the Crimea. They consisted of small cylinders of copper containing a detonating composition, and were made up in the form of ordinary cartridges, suitable for being discharged from muskets. On hitting objects these projectiles burst with great violence. Some specimens of these explosive balls were found in Sebastopol after the conclusion of the siege, and it was only then, M. Scrive remarks, that a key was obtained to some wounds of a frightful character, which could not be accounted for by the action of ordinary bullets, or of fragments of shell.* No similar observation is recorded in the British official surgical history of the war; but a recent writer in the *Times* newspaper has referred to the fact of some English troopers having been wounded by explosive bullets at the action of Balaklava.† They could have been employed only to a very limited extent, however, during the Crimean war, owing to the nature of the weapons with which the Russian troops were then armed; while now with breech-loading arms they can be used, if considered advisable, without any limit.

As, however, it has been announced that the principal European Powers, on the proposal of the Russian Government, have come to an agreement not to employ explosive rifle-balls in future warfare, the effects of such missiles as regards the wounds inflicted by them hardly needs further reference here.

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* *Relation médico-chirurgicale de la campagne d'Orient*, par le Dr. Scrive, &c., pp. 438. Paris, 1857.

† See a letter signed F.R.C.S. in the *Times* of December 16, 1868. It is a curious fact, as this correspondent remarked, that the Russians who first made use of explosive bullets in war should be the first nation to propose the abandonment of such projectiles.

QUALITIES OF THE PROJECTILES BY WHICH GUN-SHOT WOUNDS ARE PRODUCED.

As gun-shot wounds in war are greatly modified in their appearances, symptoms, and gravity by the varieties of missiles which produce them, some remarks on the missiles themselves and their qualities are rendered necessary. There is not space in a limited article like the present for entering fully into this part of the subject, but such leading points as the kinds of projectiles by which they are usually caused, with the influence of their form, weight, and of the varying degrees of velocity impressed upon them, will now be briefly considered.

Kinds of projectiles.—The projectiles used in warfare of the present day are, cannon and musket shot, shells of various kinds, hand-grenades, case-shot, and other minor varieties of such missiles. These are the ordinary instruments of *direct* gun-shot wounds in warfare; but in addition, there are numerous sources of *indirect* wounds, resulting from the discharge of cannon and musketry. These are stones or other hard substances struck from parapets or from the surface of the ground by cannon-shot; splinters of wood from platforms and frame-work, or of iron from gun-carriages; fragments of bone from wounded comrades, or articles in their possession; and any other miscellaneous objects which may happen to come into contact with the solid ball, or shell, in its course.

A gun-shot wound, whether received from a direct or indirect projectile, may be complicated by the entrance of secondary extraneous bodies of various kinds; most commonly, portions of the cloth or other parts of the dress worn by the person wounded. Such accompaniments of the primary projectiles often have a special bearing on the progress of cure of wounds.

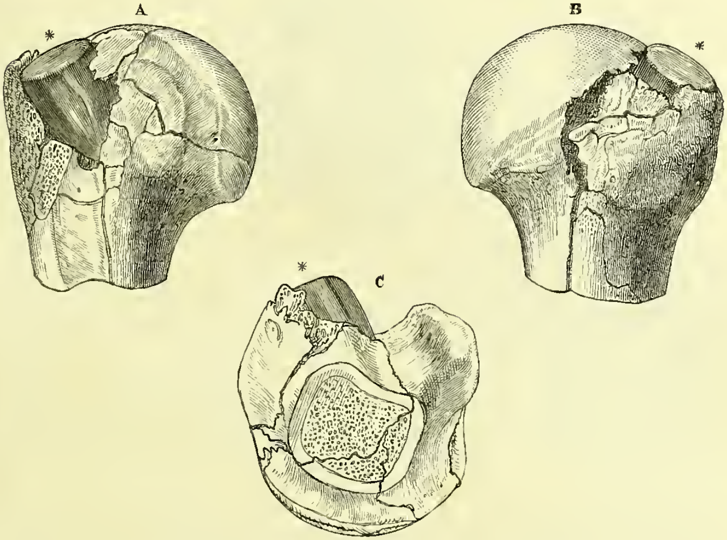
Forms of projectiles.—The projectiles above enumerated present several varieties of forms. The chief are: 1. Spherical—as cannon-balls, grape, musket and pistol shot, and shells; 2. Cylindro-conoidal—as balls belonging to rifled cannon and rifled muskets; 3. Irregular, but generally bounded by linear and jagged edges—as fragments of shells and splinters.

In the largest kinds of balls, such as are projected from field-pieces, or guns of position, the form offers little subject for consideration to the surgeon. So long as there is momentum enough to carry forward the mass of iron of which these missiles are composed, so long will their weight be the most important ingredient in the production of the wounds inflicted by them. But with regard to musket-shot, the form presents several features worth the consideration of military surgeons. In discussing the subject, however, it must not be omitted to be borne in mind, that we have no experience of the effects of round musket-balls propelled with the same amount of force as recent improvements in fire-arms have given to balls furnished with a conical vertex; although, in the old two-grooved rifle, with its belted round ball, a momentum was procured far exceeding that of the common smooth-bore musket. The change in form from the round to the prolonged cylindro-conoidal ball seems to derive its chief importance in surgery from the conical end possessing the mechanical characteristic of a wedge, while the former acted simply as an obtuse body. From this quality the power of penetration of conical bullets is greater, independent of the increased momentum communicated to them by the construction of the weapons from which they are discharged. Thus, supposing one of the old musket-bullets to strike a limb at 80 yards, and an Enfield rifle conical bullet of the same weight at 800 yards, the rate of velocity being similar in each case, the injury from the latter may be expected to be considerably greater than that from the former, on account of its shape. The wedge-like quality of the conical bullet is rendered particularly obvious on its being driven into the shafts of the long bones of the extremities. The solid osseous texture of which the cylindrical portion of these bones is composed, is split up into fragments, having mainly a direction parallel with the central cavity; and fissures not unfrequently extend from the seat of injury to their terminations in the joints, of which they form component parts. Such results were scarcely ever noticed from the impact of round balls. The bone might be comminuted, but the fragments were of a more cuboid shape, and the long fissuring did not usually occur.

The same difference of effect may be observed on comparing the injury produced upon the apophysis of a bone by a conoidal bullet with that produced by a round ball. The splintering caused by the conoidal projectile will generally be found to extend to a considerable distance into the shaft, while the injury from the round one is usually limited to the apophysis itself. This difference becomes of practical importance when the subject of the treatment of such an injury by resection is considered; not only as regards the extent of bone necessary to be removed, but also as regards the progress of cure, and the general results of the operation.

The following drawings of two shoulder-joint wounds (Figs. 22, 23), one caused by a round, the other by a conoidal bullet, during the Crimean campaign, well illustrate the relative effects just described. They are the more interesting as regards the question of the influence of *form*, inasmuch as in each case the same part of the bone has been struck, and the momentum, or force, of the two projectiles has been also alike, as evidenced by their corresponding depth of penetration. The sketches are taken from specimens in the Museum of the Royal College of Surgeons of England.*

Fig. 22.



A and B show the condition of the head of a humerus, which has been struck by a *conoidal* ball at the anterior aspect of the greater tuberosity. The bullet (shown by the asterisk *) has entered apex first, and is embedded in the cancellous tissue, its base being on a level with the surface of the bone. Great splintering has followed, and C shows the fissured condition of the shaft, at the part where the operation of resection has been performed. It is probable that these fissures extended some distance in the shaft below the line of resection.

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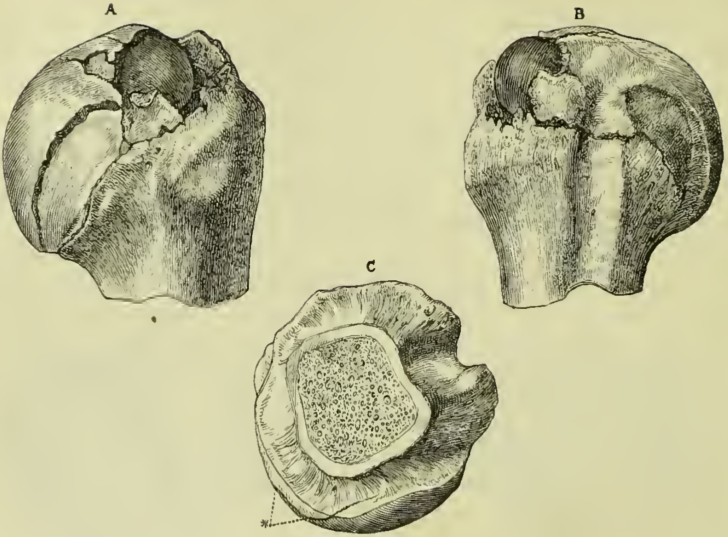
* Preps. No. 2926 B, and No. 2926 D. For histories of the cases, see *Descriptive Catalogue of the Pathological Specimens in the Museum of the Royal College of Surgeons of England*, pp. 92, 93.

Fig. 23.



A and B show the condition of the head of a humerus which has been struck by a *round* ball in nearly the identical spot at which the specimen represented in Fig. 22 had been struck. The round ball, like the conoidal, has also entered to a distance corresponding with its own depth, its surface being on a level with that of the surrounding bone. Although the head of the bone has been greatly shattered, as shown in A, the rending asunder, or splintering, is very limited. and the saw, in resecting the injured head, has passed through the shaft (see C) without crossing a single fissure ; and this, notwithstanding the operation has been performed somewhat nearer to the neck of the bone than in the preceding instance.

Another result of the tapering form of the conical bullet is, that it is less exposed in its course through soft parts of the body to opposition from tendons, and other long and elastic structures, so frequently noticed to stay the progress of spherical shot. If not dividing them by direct impingement, it readily turns them aside; and it is partly due to this pointed shape, therefore, as well as to increased force, that, as will be noticed hereafter, the lodgment of balls is now so rare in comparison with the experience of former wars.

Weight of projectiles.—Much has been written on the comparative surgical effects of bullets of various weights and sizes; but these qualities do not, on consideration, excite so much practical interest in the mind of the surgeon as it might at first appear they are calculated to do. Some very heavy bullets were used by the Russians in the defence of Sebastopol, nearly one-third heavier than any employed by the troops opposed to them. Such bullets, if of like form and density, and propelled with equal velocity, would obviously inflict injuries, especially against osseous structures, which offer great resistance, wider in proportion to their greater size and momentum; but in respect to simple flesh-wounds, the increased size of the wound left by the larger ball would make little difference in the gravity of the wound, or the time required for its cure, while the escape of foreign substances, which it might happen to carry with it, would be facilitated by the freer means of exit and increased discharge from the surface. Mr. Guthrie mentions, that having had a wide field for observation in the effects of the heavy British musket-balls, sixteen to the pound, on the French wounded, he did not think them more mischievous in their results than the French musket-balls, twenty to the pound, on the English soldiers; while the advantages of carrying a lighter musket and greater number of rounds of ammunition were on the side of our adversaries. It is understood that in warfare the object is not so much to destroy life as to disable antagonists, and the smaller size has been supposed to be fully equal to this object by the British military authorities of the present day. When the Enfield rifle was given to the army, the weight of the ball was reduced two drachms and a half below that of the ball which had been used with the Minié rifle, previously in use. The weight of the bullet used with the Minié rifle was 680 grains; with the muzzle-loading Enfield it was reduced to 530 grains. The bullet of the present converted Enfield breech-loader is still less in weight, being only 480 grains. This projectile is destined to be still further reduced in bulk, as combatants find the bore of the Enfield rifle to be needlessly large. Its diameter is one-tenth of an inch greater than that of the French Chassepot rifle, and the bullet used with it, as well as the cartridge, is considerably heavier: hence a French soldier can now carry 135 rounds to an English soldier's 90 rounds—a military advantage which, it might be supposed, would not be allowed to continue. But it does not appear likely that the contemplated new projectile, though less in diameter, will be less in weight than that of the present breech-loading Enfield; indeed, the bullet most recently recommended for adoption has precisely the same weight, viz. 480

grains.* After all, however, within the moderate limits which must be preserved to suit the circumstances of infantry soldiers, the form, hardness, and velocity of musket-balls must be the qualities of interest to the surgeon in connection with the wounds inflicted by them, rather than their relative weight.

Course of balls.—Another influence resulting from the form and average momentum of modern small-arms projectiles may be noticed. Of the circuitous and unexpected directions pursued by bullets in their passage through the human frame, which were formerly so common, we are not likely to see many instances now that the rifle is the weapon chiefly employed. The conoidal shape of the ball, and the force with which it is propelled, have had the effect, among others already named, of changing the indirect and tortuous course which was so characteristic of the ball from the smooth-bored musket. The latter, bearing a force that scarcely carried it true to a mark at eighty yards, and receiving, as it left the firelock, an impulse which caused it to revolve on its axis at right angles with the line of flight, was deflected by the most trifling obliquity of surface, by the resisting obstacle of a bone, by tendons, or the aponeuroses of muscles, or even by the elastic resilience of muscles themselves in a state of action, when the relative direction of their fibres was favourably placed to exert this influence. The Enfield cylindro-conoidal bullet, armed with a force that will carry it to a given spot distant 1,000 yards or upwards, flies spinning on an axis coincident with its line of flight, penetrates the softer tissues in a straight line, and on meeting bone, as before noticed, enters it like a wedge. When a bullet of this kind strikes an object point blank, it is always the apex of the conical part which first meets the object struck; and, if sufficient resistance be met with, it is this apex which becomes first compressed, and turned back. When it strikes a solid object lying nearly parallel with its line of flight, the ball is planed, as it were, from its apex towards its base.

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* The bullet recommended by the Small Arms Committee for adoption with the Martini-Henry rifle, with which it is proposed to arm the British infantry, instead of the converted Enfield rifle, is without the hollow base, baked clay plug, and wooden plug in the head, which are features of the bullet in present use. It is, instead, solid and wholly made of lead hardened with tin; and hence, though only ·45 of an inch at its widest part in diameter, instead of ·55 of an inch as the Enfield, it is not reduced in weight. The weight of the French Chassepot bullet is 24·50 grammes, or a fraction over 378 grains, and is therefore 102 grains lighter than the Enfield bullet and than the newly recommended Martini-Henry bullet. The combatant advantages connected with the lightness of the Chassepot ammunition are stated to be outweighed by the following advantages on the side of the Martini-Henry weapon and its projectile: greater accuracy of flight, longer range, flatter trajectory, higher penetrative power, increased rapidity of fire, and certain other advantages which need not be mentioned here, as they appertain to the rifle itself rather than to the qualities of the bullet projected by it, and therefore do not influence either the number or nature of the wounds that may be caused by the weapon.

It will often appear, at first examination, that the track of a cylindro-conoidal bullet, even at full speed, is widely removed from a straight line, especially when this class of injuries is new to the surgeon. But it usually is not difficult to reconcile the apparent irregularity in the course the projectile has taken if the many varied positions in which the body and its parts are liable to be placed are called to mind, and if, when making the examination, the surgeon takes care to place the patient in a similar posture to that he was in when struck. A certain allowance must also be made for the spasmodic actions of the various muscles among themselves, and the momentary displacement of other structures, at the instant the injury is received.

Degree of velocity.—The velocity of motion of projectiles is an important ingredient in the consideration of the wounds produced by them.

The effects of different rates of velocity on wounds are seen in the variations which occur in proportion to the distance which the missile has travelled before inflicting the injury. A cannon-ball which, with but slight velocity of motion added to its weight, would knock a man over, at ordinary speed will carry away a limb without disturbing the general equilibrium of the body. A musket-ball that would be arrested half way through a limb, is now replaced by a ball which, at like distance from the point of discharge, will pass through several bodies in succession.

The increased velocity, or, in other words, greater force, of modern projectiles, exhibits its effects in two directions: locally, by the greater destruction of the tissues in the track of the projectile; and constitutionally, by greater disturbance to the nerve-force of the whole system. The component parts of that portion of the organised fabric through which a bullet, travelling at the rate of several miles per minute, cleaves its way, are inevitably deprived of their vitality. Instances are quoted by authors, of gun-shot wounds having healed by simple adhesion; but such examples are not met with when rifle-bullets retaining their original form have made an opening through a part of the body. Bullets which have happened to be brought into collision with stones or other hard substances on the ground before striking a soldier, and which, in consequence, have not only been deprived of part of their force, but have also been flattened into a mass with thin sharp edges, occasionally cause superficial wounds, which may readily be caused to heal by first intention, but these are essentially different from the wounds produced by rifle projectiles under ordinary circumstances.

The splitting and destructive effects of conical balls on the shafts of the long bones of the extremities have already been mentioned when referring to the peculiarities of their shape. But, together with the quality of shape, the amount of momentum is a necessary ingredient in estimating this result. The old round balls—partly from their form, but also from the imperfect mechanism of the firelocks from which they were discharged, and consequent minor degree of velocity imparted to them—on striking bones, would simply be turned away from the direct line: or, failing this, would knock out a portion of the shaft without further fracture; or, having perforated on one side, remain in the cancellated structure; or be simply flattened without penetrating. It seems not unlikely, also, that the modern conical bullets are denser, from the circumstance of their manufacture by mechanical pressure, than bullets which have been cast in moulds. The influence of density with respect to power of penetration is very great. In comparing the two most perfect of modern English rifles which have been employed hitherto, the Enfield and the Whitworth, the projectiles and charges being of the same weight, when lead is used, the penetration at 800 yards is one-third greater with the Whitworth than with the Enfield; but when a less yielding projectile is used with the Whitworth (as when the lead is mixed with tin), its penetration is more than four times greater than that of the Enfield. Whether this cause operates or not, the fact is certain that conical balls at their average speed exhibit an overpowering force over all the structures, bone included, with which they come into contact in the human body, and are comparatively rarely met with flattened, or so much altered in form as round bullets were formerly under like circumstances.

Spent balls.—In connection with degree of velocity the subject naturally occurs of what are called ‘spent balls,’ or large projectiles moving at low rates of speed. After a cannon-ball has ceased to pursue its course through the air, or to proceed by ricochet, it not unfrequently travels to a considerable distance, rolling along the surface of the ground. When its rate of movement is not much faster than that at which a man can walk, and when to all appearance it might be stopped by the pressure of the foot as readily as a cricket-ball, it yet possesses the power of inflicting serious injury on such an attempt being put into execution. This power is easily understood, if the amount of force is remembered which must still be inherent in the cannon-ball for it to overcome the inertia of its own mass, and the resistance to which it is exposed in passing over the ground on which it is rolling. It is this force, multiplied by the weight of the ball, which gives it the destructive power. If such a ball is brought into collision with the foot of a person, destruction generally ensues to such an extent as to necessitate amputation. Should it impinge on other parts of the body, as in the instance of a man lying on the ground, it may cause fatal rupture of internal organs, and that without exhibiting external evidence of the amount of injury it has inflicted. So also, though powerless to carry away a limb, it may still cause comminuted fractures of bones and extensive contusions of the softer structures.

Lodgment of balls.—Low rate of velocity leads to musket and other balls lodging in various parts of the body. When the smooth-bore musket was in common use, lodgment of balls was of frequent occurrence. In the first place, from absence of sufficient velocity to effect its passage out of the body, and secondly, from its liability to be diverted from a direct line, a round ball might be arrested in its progress at any distance from its point of entrance. Conical balls lodge when their velocity has become nearly expended before entering the body; or, from peculiarity in the posture of the person wounded, a ball having had force enough to traverse a limb, may afterwards enter into another part of the body, and lodge. A ball may reach a part so deep, in the muscles of the back, for example, or be so far removed from the aperture of entrance, as to elude all attempts on the part of the surgeon, at the time of examination of the wound, to discover its retreat. Or it may have reached some position from which the surgeon fears to take the necessary steps for its extrication, judging the additional injury that would thus be inflicted more mischievous than the probable effects of allowing the ball to remain lodged.

Unextracted balls lead to consequences varying according to the site of lodgment and state of constitution of the patient. If the ball have become fixed in the body of a muscle, or in its cellular connections, adhesive inflammation may be established around it, and, in time, a dense sac be thus formed, in which the ball may remain without causing any, or but very slight, inconvenience. But although encysted, a ball may press upon nerves and give rise to pain and much uneasiness; or it may change the position of its first lodgment, under the effect of gravitation, or the impulse of muscular actions, and may then become so placed as to embarrass the person in certain movements of the body. Sometimes the lodged projectile will not become provided with a protecting envelope of the kind above named, but will excite continued irritation and give rise to chronic abscess; sometimes the abscess will become healed, but will reopen from time to time under the influence of various exciting causes; and these cases usually end, though it may be years after the date of the original injury, by the bullet appearing so near the surface that there ceases to be any difficulty in its removal.

Symptoms of Gun-shot Wounds.

Having considered some of the leading qualities of the projectiles by which gun-shot wounds are produced, it is now necessary to notice some of the characteristic features and symptoms of the wounds themselves.

The chief diagnostic marks of these injuries in their early condition are those external appearances which result from the physical effects produced locally by the stroke of the projectile. Other symptoms result from injury done by the projectile in its course through the deeper tissues; such as pain, numbness, paralysis, from lesion of nerves; hæmorrhage, from lesion of blood-vessels; together with particular symptoms characteristic of special organs which may have chanced to be wounded by the projectile during its passage. One general symptom, designated 'shock,' and indicative of constitutional disturbance is an usual accompaniment of all gun-shot wounds, but the extent to which it is exhibited varies greatly in different cases.

External signs.—The external distinguishing signs of a penetrating gun-shot wound are generally manifest enough. But, although possessing certain universal characteristics, they vary so much, according to the differences already described in the forms of the missiles causing the injuries, their velocity, the part of the body struck, and the position of the patient relative to the projectile at the time of injury, that it is necessary shortly to describe some of these variations.

When a cannon-ball at full speed strikes in direct line a part of the body, it carries away all before it. If the head, chest, or abdomen are exposed to the shot, an opening corresponding with the size of the ball is effected, the contiguous viscera are scattered, and of course life is at once extinguished. If it be part of one of the extremities which is thus removed, the end remaining attached to the body presents a stump with a nearly level surface of darkly contused, almost pulpified, tissues. The skin and muscles do not retract, as they would had they been divided by incision. Minute particles of bone will be found among the soft tissues on one side, but the portion of the shaft of the bone remaining *in situ* is probably entire.

In a ricochet shot, or in any case where the force of the cannon-ball is partly expended, the extremity, or portion of the trunk, may be equally carried away, but the laceration of the remaining parts of the body will be greater. The surface of the wound will be less even. Muscles will be separated from each other, and hang loosely, offering at their divided ends little appearance of vitality; spiculæ of bone of larger size will probably be found among them; and the shaft may be found shattered and split far above the line of its transverse division. The injury to nerves and vessels may be proportionately higher and greater. Occasionally it happens, even where the limb seems to have been struck in direct line, that it is nevertheless not completely detached, but remains connected by shreds of the skin and parts of the tissues jammed together, on which the bone, reduced to minute fragments, is mixed with the contused muscles and other soft parts in a shapeless mass.

If the speed be still further diminished, so that the projectile becomes what has been explained to be a 'spent ball,' there will not be removal of the part of the body struck, but the external appearances will be limited usually to contusion and laceration of the soft parts, or extensive ecchymosis and tumefaction without division of surface.

Should the cannon-ball strike in a slanting direction, the external appearances of the wound will be similar to those just described, according to its velocity, modified only in extent by the degree of obliquity with which the shot is carried into contact with the trunk, or with the extremity wounded. Occasionally, however, in exceptional cases, there will be no external appearance of injury, notwithstanding the existence of serious internal disorganisation. The rationale of such phenomena will be presently described.

Fragments of heavy shells generally produce immense laceration and separation of the parts against which they strike, but do not carry away, or grind structures, as round shot do. Ordinarily, the line of direction in which they move forms an angle more or less acute, with the part of the body wounded, and the injury done is rather superficial than deep. When they happen to strike in a more direct line, so as to penetrate and sink beneath the surface, the external wound is mostly smaller than the fragment itself, from the projectile not having had force enough to destroy the vitality and elasticity of the skin and other soft parts through which it has entered, so that these structures partially contract around the wound, and so lessen the size of its opening.

Small projectiles, with force enough to penetrate the body, leave one or more openings, the external appearances of which also vary according to the form and velocity of the projectiles by which they are caused. The appearance of a wound from a rifle-ball, at its highest rate of speed, may be sometimes witnessed in cases of suicide. A soldier, in thus destroying himself, mostly stoops over the muzzle of his firelock, pressing it against the upper part of his body, and springing the trigger by means of his foot or a piece of cord connected with it. The muzzle is usually applied beneath the chin. In such a case, a circular hole, without any puckering or inversion of the marginal skin, together with dark discoloration of the integument for several inches round, is observed at the wound of entrance. The vertex of the head is shattered; fragments of the parietal and occipital bones, together with small portions of brain, are carried away and scattered about; those bones which are not broken are loosened from their sutures; the great mass of the brain is torn to pieces, but held within by its membranes; the superficial vessels of the face are distended with blood. These effects are not wholly due to the passage of the ball; but partly to the flame and smoke from the ignited gunpowder jetting out at the mouth of the musket, and in part also to the expansive force exerted within the cavity of the cranium, by the gases resulting from the explosion of the gunpowder.

When a musket-ball strikes a limb at some distance from the weapon by which it was propelled, but while still preserving great velocity, the appearances of the wound of entrance are different from those of the opening last described. An opening of about the size of the projectile is now observed, sometimes irregularly circular, with edges generally a little torn ; sometimes consisting of three triangular flaps, which, on being lifted up, can be made to meet at their apices in the centre of the opening. In either case, the whole wound presents a slightly inverted aspect. There may be darkening of the marginal skin, of a livid purple tinge, from the effects of contusion or from dislodgment of powder which was adhering to the bullet, or it may be simply deadlike and pale. Should the ball have passed out, the wound of exit will be probably larger than the projectile, more irregular and torn than the wound of entrance, with slight eversion of its edges, and with protrusion of the subcutaneous fat which is thus rendered visible. These appearances are the more easily recognised the earlier the wound is examined. They are more obvious if a round musket-ball has caused the injury than when it has been inflicted by a cylindro-conoidal bullet. Indeed, with the latter, when it has passed, apex forwards, through the soft tissues of an extremity of the body at full speed, when it has neither struck a bone nor carried any foreign body before it, it is often very difficult to distinguish by its appearance the wound of entrance from that of exit. In medico-legal investigations concerning gun-shot wounds, it sometimes is still a matter of great importance to decide this point; but to the military surgeon, more especially from the circumstances connected with the new projectiles, it has become a subject of much less practical interest than it formerly was. When the indirect and tortuous penetration of balls was the rule rather than the exception, a knowledge of the spot at which the ball entered was often useful in diagnosing the mischief it had probably committed in its passage, and in determining the part of the wound where foreign bodies might be supposed to be carried and to be lodging. When the track of the ball is nearly in a straight line, as now so frequently happens, such information cannot be looked for from knowing the relation of either opening to the course of the projectile.

The appearances of wounds resulting from penetrating missiles of irregular forms, as small pieces of shells, musket-balls flattened against stone, and others, differ from those caused by ordinary bullets in being accompanied with more laceration, according to their length and form. Being usually projected with considerably less force than direct missiles, such projectiles ordinarily lead only to one aperture, that of entrance.

Internal wounds without external marks.—Among the wide variety of injuries from gun-shot, there have not unfrequently been noticed instances in which serious internal mischief has been inflicted, without any external marks of violence to indicate its having resulted from the stroke of a projectile. These peculiar cases have been before casually alluded to when describing the external appearances of wounds caused by cannon-balls striking a part of the body in a slanting direction. An important viscus of the abdomen has been ruptured, yet no bruising of the parietes observable; symptoms of cerebral concussion have shown themselves, yet no injury of the scalp to be detected. Even bones have been comminuted without any wound of the integuments or appearance of injury. The records of the Crimean campaign afforded not unfrequent examples of such wounds. In one case an English soldier had the whole shaft of a humerus shattered to pieces by a cannon-shot, yet the skin was as sound and as white as if it had not been touched. Two cases occur, in the French records, of fracture of the fore-arm without any external apparent lesion; in one, the internal structures were reduced to a mass of pulp. The difficulty of reconciling the several facts noticed in such instances, together with the vague descriptions by patients of their sensations, led surgeons to seek an explanation for them in the supposition that masses of metal projected with great velocity through the air might inflict such injuries indirectly by aërial percussion. Either the air might be forcibly driven against the part injured by the power and pressure of the ball in its flight, or a momentary vacuum might be created, and the forcible rush of air to refill this blank might be the origin of the hurt. Electricity has also been called into aid in explaining these injuries. All these hypotheses are now abandoned. So many observations have been made of cannon-balls passing close to various parts of the body, as near as conceivable without actual contact, without any such consequences as those attributed to windage, as to lead to the necessary conclusion that the theory must in all instances have been fallacious. Portions of uniform and accoutrements have been torn away by cannon-balls without injury to the soldier himself. Even hair from the head has been shaved off, and cases are on record where the external ear and end of the nose have been carried away without further mischief.

The true explanation of the appearances presented in those cases which were formerly called 'wind-contusions,' appears to rest in the peculiar direction, the degree of obliquity, with which the missile has happened to impinge against the elastic skin, together with the relative situation of the internal organs injured to this missile and to other hard substances in their neighbourhood. The surface itself is not directly torn or cut into, because the impact of the projectile has not been sufficiently direct to effect an opening; but the parts beneath are crushed by the pressure to which they have been subjected between the combined influence of the weight and momentum of the ball on one side, and of some hard resisting substance on the other. Thus, on a cannon-ball passing across the abdomen, the elasticity and ready mobility of the skin may enable that structure to yield to the strain to which it is exposed, while viscera are ruptured by the projectile forcing them against the vertebral column. So the weight of a ball passing obliquely over a fore-arm may possibly crush the bone between itself and some hard substance against which the arm may be accidentally resting, without lesion of the interposed skin. Baron Larrey, who examined many fatal cases of this kind, relates that he always found so much internal disorganisation as to leave no doubt in his mind of its being the result of contact with the ball. He explained the absence of superficial lesion, by the surface having been struck by cannon-balls in the latter part of their flight, when they had undergone a change of direction from straight to curvilinear, and acquired a revolving motion, owing to atmospheric resistance and the effect of gravitation. In such a condition, he argued, they would turn round a part of the body, as a wheel passes over a limb, in place of forcing their way through it; and while elastic structures would yield, bones and muscles, offering more opposition, would be bruised or broken.

Pain.—The amount of pain which follows a gun-shot wound, more particularly one from a bullet, is a symptom which varies very much in degree according to the kind and situation of the wound, the condition of mind, and the state of constitution of the soldier at the time of its infliction. The instantaneous suddenness of the injury, and the previous occupation of the soldier's thoughts, usually prevent him from noting his own sensations with any approach to accuracy. It will sometimes happen that patients who have suffered simple flesh-wounds, will tell the surgeon they were not aware when they were struck; and the truth of such statements is attested by the fact that instances not unfrequently occur of soldiers continuing in action for some time without knowing they had been wounded. Sometimes the pain from the shot is described as a sudden smart stroke of a cane; in other instances as the shock of a heavy intense blow. Occasionally, when the trunks of nerves are directly injured short of division, as when they are violently pushed aside by a bullet, the pain will be referred to a distant part not involved in the track of the wound. Lieutenant M. of the 19th Regiment, was wounded by a musket-ball at the assault of the Redan, on September 8, 1855. His sensations led him to imagine that the upper part of his left arm was smashed, and he ran across the open space in front of the works supporting the arm which he supposed to be broken. On arriving at the advanced trench, he asked for water; on trying to drink, he found that his mouth contained blood, and that he was unable to swallow. The arm on examination was found to be uninjured, but a ball had passed from right to left through his neck, and from its direction had no doubt struck some portion of the lower cervical or brachial plexus of nerves. When a ball does not penetrate the flesh, but simply inflicts a contusion, the pain is often described by patients to be more severe than it is by others in whom a bullet has effected an entrance.

Shock.—When a large bone is suddenly shattered, a cavity penetrated, an important viscus wounded, a limb carried away by a round-shot, the most prominent symptom is the general perturbation and alarm which in most cases instantaneously supervene on the injury. This is generally described as the 'shock' of a gun-shot wound. The patient trembles and totters, is pale, complains of being faint, perhaps vomits. His features express extreme anxiety and distress. This emotion is in great measure instinctive; it is witnessed in the horse hit mortally in action, no less than in his rider; and seems to be sympathy of the whole frame with the part subjected to serious injury, expressed through the nervous system. This shock is more or less persistent according to circumstances. Examples seem to show that it may occasionally be overpowered altogether, even in most severe injuries, by moral and nervous action of another kind, by a state of mental tension; but this can rarely happen when the injury is a vital one. Panic may lead to similar symptoms of shock, although the wound is of a less serious nature. A soldier, having his thoughts carried away from himself—his whole frame stimulated to the utmost height of excitement by the continued scenes and circumstances of the fight—when he feels himself wounded, is suddenly recalled to a sense of personal danger; and if he be seized with doubt whether his wound is mortal, depression as low as his excitement was high may immediately follow. This depression will vary in degree according to individual character and intelligence, state of health, and other personal peculiarities. For while, on the one hand, numerous examples occur in every action of men walking to the field-hospital for assistance almost unsupported and with comparatively little signs of distress, after the loss of an arm or other such severe injury; on the other, men whose wounds are slight in proportion are quite overcome, and require to be carried.

As a general rule, however, the graver the injury, the greater and more persistent is the amount of 'shock.' A rifle-bullet which splits up a long bone into many longitudinal fragments inflicts a very much more serious injury than the ordinary fracture effected by the ball from a smooth-bore musket, and the constitutional shock bears like proportion. When a portion of one, or of both, lower extremities is carried away by a cannon-ball, the higher towards the trunk the injury is inflicted, the greater the shock, independent of the loss of blood. Some writers in accounting for 'shock' lay stress on the concussion, and general mechanical effects on the whole body, including the nerve centres, from the momentum of the iron shot.* To a certain extent this may be true; but, judging from analogy in physics, the greater the velocity, and consequently the momentum, of a ball carrying away a limb, the less would the concussion of the trunk and distal parts of the body be. A pistol-ball at full speed will take a circular portion out of a pane of glass without disturbing the remainder; if the speed be much slackened, as when fired from a distance, it will shake the whole pane to pieces.

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* In the *Medical and Surgical History of the War against Russia in the Years* 1854–55–56, published by authority, vol. ii. p. 265, the physical effects of concussion in producing 'shock' are strongly dwelt upon. It is remarked: 'The shock of the accidents frequently witnessed by the military surgeon differs, often in a very material degree, and possibly in kind also, from that witnessed in civil life. When a cannon-shot strikes a limb and carries it away, the immense velocity and momentum of the impinging force can scarcely be supposed to have no physical effect upon the neighbouring or even distant parts indepen-

That true 'shock'—*ébranlement* of French writers—as distinguished from shock resulting from violent concussion, from mental depression after unusual excitement, or from the effects of groundless alarm on the part of a patient, is a phenomenon the essential relations of which are connected with vital force, and with that endowment of the organisation only, may be judged from observation of cases in which the direct result of the wound is inevitably fatal, including many where no physical effects on neighbouring parts from concussion could possibly be produced. In such injuries the 'shock' remains, from the time of first production of the fatal impression till life is extinguished. And the practical experience of every army surgeon teaches him that where a ball has entered the body, though its course be not otherwise indicated, the continuance of shock is a sufficient evidence that some organ essential to life has been implicated in the injury. That the shock of a severe gun-shot wound may be complicated with other symptoms, or that some of its own symptoms may be exaggerated from other causes—hopes disappointed, the approach of death, and all the attendant mental emotions—scarcely affects the question at issue; for its existence, independent of these complications, in all such cases is undoubted.

Primary Hæmorrhage.—This is one of the accompaniments of gun-shot wounds, which, as might be expected, varies very greatly in degree according to the size and situation of the

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dent of, and in addition to, the 'shock' in the ordinary acceptation of the term, which would result from the removal of the same part by the knife of the surgeon, or the crushing of it by a heavy stone or the wheel of a railway wagon. . . . In the great majority of cases, the whole frame is likewise violently shaken and contused, and probably, independent of the physical effects, a further vital influence is exerted, which exists in a very minor degree, if at all, in the last-named injuries, and may possibly depend upon the ganglionic nervous system.'

blood-vessels wounded. In some gun-shot wounds there is hardly any perceptible hæmorrhage, a mere oozing: in others, the hæmorrhage is to such an extent, as, of itself, to cause speedy death. Much difference of opinion has been expressed concerning the number of deaths which result after gun-shot injuries from primary hæmorrhage on a field of action; and the question of the proportion of fatal consequences from this cause, to deaths from other causes, in warfare, it still an open one. There is no doubt about the fact that primary hæmorrhage of a serious nature from gun-shot wounds does not often come within the surgeon's observation. If hæmorrhage occur from one of the main arteries, and is unattended to, it probably proves rapidly fatal; and most surgeons after an action are too much occupied with the urgent necessities of the living wounded to spare time for examining the wounds of the dead, who are usually buried as soon as practicable on the field where they have fallen. Thus many surgeons speak of primary hæmorrhage being exceedingly rare, because they have not met with it in their own experience; a statement which more extended observation might, perhaps, have considerably modified. M. Baudens, on the other hand, referring to his service in Algeria, has remarked that he has often found, by examination of the dead lying on the field of battle, that death had resulted from primary hæmorrhage.

Ordinarily, so far as the wounds from great projectiles to which the surgeon's attention is called are concerned, and in which some of the larger arteries have been divided, the primary hæmorrhage is generally found to have been comparatively small in quantity and of short duration—a sudden flow at the moment of injury, and nothing more. When a part of the body is carried away by round shot or shell, the divided arteries are usually observed to be nearly in the same state as they are found to be in when a limb is torn off by machinery. The lacerated ends of the middle and inner coats are retracted within the outer cellular coat; the calibre of the vessel is diminished, and tapers to a point near the line of division; it has become plugged within by coagulum; and the cellulo-fibrous investing sheath, and the clot which combines with it, form on the outside an additional support and restraint against hæmorrhage. When large arteries are torn across, and their hæmorrhage is thus spontaneously prevented, they are seldom withdrawn so far but that their ends may be seen protruding and pulsating among the mass of injured structures; yet, though the impulse may appear very powerful, further loss of blood is rarely met with from such wounds.

The smaller forms of projectiles, again, do not appear to lead to primary hæmorrhage so frequently as might be expected, if we except small fragments of shells, splinters of wood, and other indirect missiles with sharp edges. These angular fragments will cause vessels to be divided, which would have escaped from being opened had they been brought into collision with missiles having smooth surfaces and convex outlines. It comparatively rarely happens, indeed, that the surgeon sees any of the larger arteries cut across by musket bullets, either round or conical. The lax cellular connections of these vessels, the smallness of their diameters in comparison with their length, the elasticity as well as toughness of the tissues forming their coats, the fluidity of their contents, and, in consequence of all these conditions, the extreme readiness with which they slip aside under pressure, constantly act as means of preservation, even although these important structures are subjected to such imminent danger as the passage of a musket-ball in their direction. Endless examples occur where a ball appears to have passed through a part of the body in the exact situation of an important artery, so that it must have been pushed aside by it, or it could not have escaped division. Mr. Guthrie has recorded a case where a ball even opened the sheath of the femoral vessels, and passed between the artery and vein, in a soldier at Toulouse, without destroying the substance of either vessel. So close was the ball, and such contusion was produced, together with, doubtless, injury to the vasa vasorum, that the artery became plugged with coagulum and obliterated. A preparation of the vessels referred to in this case is in the Museum at Netley. Another case is mentioned by Mr. Guthrie, where the direction of a ball between the left clavicle and first rib, and permanent diminution of the pulse in the arm on the same side, led to the conclusion that the subclavian had escaped direct destruction by the missile in a similar way. I have several times met with examples of obliteration of vessels, produced in a similar way, among men invalided from the effects of wounds at Chatham and Netley.

The position of a limb or artery when struck may prevent such a happy escape. On examination of the wound of Captain V., of the 97th Regiment, whose death led to so much interest in England, I found that he had been struck by a ball which had penetrated the right axilla and divided the axillary artery. His arm had apparently been stretched out when he received the injury, probably in the act of holding up his sword. The night was very dark, the distance from the place where the sortie took place in which he was wounded to the camp-hospital was more than a mile and a half, and he sunk from hæmorrhage while being carried up. Mr. Guthrie mentions the cases of two officers who were killed, almost instantaneously, one by direct division of the common iliac artery, the other of the carotid. The death of an officer from division of the femoral artery is recorded in the *Surgical History of the Crimean War*. Other cases are mentioned, though not immediately fatal, of a wound of the femoral vein and profunda artery in the same subject from a conical bullet; and one of the popliteal artery and vein, also from a rifle-ball.

PROGNOSIS.

In estimating the probable issue of a particular wound, not only its nature and the patient's state of health at the time must be taken into account, but, if he be a soldier, his previous service and the diseases under which he has laboured during it, and the circumstances in which he is placed with respect to opportunity of proper care and treatment must also be carefully weighed. The time which has elapsed after the receipt of the injury is another important matter in forming a prognosis. The difficulties which have been already enumerated in the way of arriving at a safe diagnosis of the true nature and extent of the injury, and the liabilities already mentioned to which a patient with a gun-shot wound is exposed, should put a surgeon on his guard against giving a hasty judgment in any case that is not very plain and simple. Military surgery abounds with examples of wounds of such extent and gravity as apparently to warrant the most unfavourable prognosis, which have nevertheless terminated in cure; while others, regarded as proportionably trifling, have led to fatal results. The mortality among gun-shot wounds is not merely dependent upon the direct effects of the injuries which have been inflicted, but is in a large proportion due to subsequent complications: secondary hæmorrhage, gangrene, erysipelas, hectic fever, pyæmia, and the results of operations required as consequences of the original wound. The amount of mortality from these secondary causes in military practice is again greatly influenced, in the first place, by the distances to which soldiers have had to be removed before reaching their places of treatment, and the modes of their removal; and, in the second place, by the opportunities which exist for hygienic arrangements, and especially for dissemination of the wounded when many wounds are caused at the same time, or upon the degree in which the importance of these influences is appreciated. Tables may be found in works showing statistically the nature and relative numbers of wounds and injuries received in various actions, with their immediate and remote consequences, as well as the results of the surgical operations they have led to: but these afford little aid towards the prognosis of particular cases, each of which must be estimated according to its own individual features and circumstances. Such tables are chiefly of value in affording indications of the average effects of different modes of treatment in wounds of a corresponding nature among patients under like circumstances and conditions. Even moral circumstances must not be disregarded in forming a prognosis. The probable issue in any given case will be very different in one soldier, who is supported by the stimulating reflection that he has received his wound in a combat which has been attended with victory, from what it will be in another, who labours under the depression consequent upon the circumstances of defeat.

Treatment of Gun-shot Wounds in General.

When the circumstances of a battle admit of the arrangement, the wounded should receive surgical attention preliminary to their being transported to the regimental or general field hospitals in rear. A slight provisional dressing, a few judicious directions to the bearers, may occasionally prevent the occurrence of fatal hæmorrhage, or avert serious aggravation of the original injury from malposition, shaking, and spasmodic muscular action, in the course of conveyance from the neighbourhood of the scene of conflict to the hospital. In the open field this attention is given by surgeons placed at what are called the 'first lines of surgical assistance,' positions near enough to the scene of fighting for the surgeons to be able to afford speedy help to the wounded, and at the same time such as to ensure, as far as practicable, protection both to the surgeons and their patients against risk of injury from shot. In siege operations, among British troops similar assistance is afforded by surgeons stationed at fixed places, generally shot-proof, constructed in the trenches; among French troops by flying field-hospitals, 'ambulances volantes,' placed in suitable sheltered spots in the ravines or roads leading down to them.

The provisional treatment should be of the simplest kind, and chiefly directed to the prevention of additional injury during the passage to the 'second line of surgical assistance' or field-hospital, where complete and accurate examination of the nature of the wound can alone be made, and where the patient can remain at rest after being subjected to the required treatment. The removal of any missiles or foreign bodies which may be readily obvious to sight or touch; the application of a piece of lint to the wound; the arrangement of any available support for a broken limb; protection against dust, cold, or other objectionable circumstances likely to occur in the transit; if 'shock' exist, the administration of a little wine, aromatic ammonia, or other restorative, in water; these and other such acts of primary attention, require little time for their execution, and may prove sources of great comfort and much service to a wounded patient. If hæmorrhage exist from injury to a large vessel, it must of course receive the surgeon's first and most earnest care. He should not trust to the pressure of a tourniquet, but secure it at once by ligature. Without this safeguard during the transport, and while in the hands of uneducated attendants, the life of the wounded man might be endangered, either from debility consequent upon gradual loss of blood, or from sudden fatal hæmorrhage. It has been recommended by some surgeons that all attendants whose duties consist in carrying the wounded from a field of battle should be directed, when bleeding is observed, to place a finger in the wound and keep it there during the transport, until the aid of a surgeon is obtained. The precise spot where compression by the finger is wanted, and the degree of pressure necessary, will be quickly made manifest to the sight by the effects on the flow of blood. This practice has been extensively followed in some armies, and it seems to be open to less objection than the use of tourniquets by men whose knowledge of their proper application must often be exceedingly limited.

On arrival at the field-hospital, where comparative leisure and absence of exposure afford means of careful diagnosis and definitive treatment, the following are the points to be attended to by the surgeon: firstly, examination and exploration of the wound, with a view to obtaining a correct knowledge of its nature and extent; secondly, removal of any foreign bodies which may have lodged; thirdly, adjustment of lacerated structures; and, fourthly, the application of the necessary dressings.

The diagnosis should be established as early as possible after the arrival of the patient at the field-hospital. An examination of the wound can then be made with more ease to the patient and more satisfactorily to the surgeon, than at a later period. Not only is the sensibility of the parts adjoining the track of the ball numbed, but there is less swelling to interfere with the examination, so that the amount of disturbance effected among the several structures, and the lodgment of any foreign bodies among them, are more obviously apparent. The importance of making a complete examination of the wound at this early period cannot be overrated.

One of the earliest rules for examining a gun-shot wound, is to place the patient, as nearly as can be ascertained, in a position similar to that in which he was in relation to the missile at the time of being struck by it. In almost every instance the examination will be facilitated by attention to this precept. Occasionally it will at once indicate the probability of injury to the surface of a bone, to joints, or other important structures, in cases where the mutual relations of the wounds of entrance and exit, in either the erect or horizontal posture of the body, would lead to no such information. Injury to nerves, inducing paralysis; contusions of blood-vessels, liable to lead to secondary hæmorrhage or gangrene, may, without sufficient circumspection in this respect, be overlooked on the patient's first admission to hospital.

When only one opening has been made by a ball, it is to be presumed that it is lodged somewhere in the wound, and search must be made for it accordingly. But even where two openings exist, and evidence is afforded that these are the apertures of entrance and exit of the projectile itself, examination should still be made to detect the presence of other foreign bodies. Portions of clothing, and, as has already been mentioned, other harder substances, are not unfrequently carried into a wound by a bullet; and, though it itself may pass out, these may remain behind, either from being diverted from the straight line of the wound, or from becoming caught and impacted in the fibrous tissues through which the ball has passed. The inspection of the garments worn over the part wounded may often serve as a guide in determining whether foreign bodies have entered or not, and if so, their kind, and thus save time and trouble in the examination of the wound itself.

Of all instruments for making a complete examination of a gun-shot wound, as well as for exploring for foreign bodies which may be lodged in it, the finger of the surgeon is the most appropriate. By its means the direction of the wound can be ascertained with least disturbance of the several structures through which it takes its course. If bones are fractured, the number, shape, length, position, and degree of looseness of the fragments may be more readily observed. Exploration by a finger will establish the fact of a joint being opened in cases where the injury to the articulation would have remained a matter of doubt if a probe had been used instead. When foreign bodies are lodged, not only is their presence more obvious to the finger direct than through the agency of a probe, or other metallic instrument, but by its means intelligence of their qualities is also communicated. A piece of cloth lying in a wound is recognised at once by a finger; while, saturated with clot, as it is under such circumstances, it will probably be mistaken for some of the natural soft parts by any other mode of examination. The index-finger naturally occurs as the most convenient for this employment; but the opening through the skin and fascia made by a rifle-ball of small diameter, is sometimes too contracted to admit of its free entrance, and in this case the substitution of the little finger will probably answer all the purposes intended. When the finger cannot reach sufficiently far, owing to the depth of the wound, the examination for foreign bodies is often facilitated by pressing the soft parts from an opposite direction towards the finger-end.

If the finger fail, even when the soft parts have been approximated, as described, and if the lodgment of a projectile be still suspected, we are compelled to make further exploration by other means. Under ordinary circumstances a long silver probe, that admits of being bent by the hand if required, is perhaps the best substitute for the finger. Elastic bougies or catheters are apt to become curled among the soft parts, and do not convey to the sense of touch the same amount of information as metallic instruments do. The probe should be employed with great nicety and care, for it may inflict injury on vessels or other structures which have escaped from direct contact with the ball, but have returned, by their elasticity, to the situations from which they had been pushed or drawn aside during its passage. Nélaton's test-probe, in which a small knob of biscuit china is prepared for taking an impression of lead or rust, on being rubbed against a leaden or iron projectile; Lecompte's stylet-pince, in which an arrangement exists for nipping off and bringing away a minute fragment of a supposed foreign body for observation; electric indicators, such as Rhumkorf's apparatus, or the more modern appliance of Mr. De Wilde, in which contact with metal at the bottom of a wound is notified by the sound of a bell; these and other such exploring instruments are chiefly useful in solving questions of lodgment in chronic cases of gun-shot wounds. Such appliances can rarely be required in the cases which come before military surgeons in field-hospitals.

The directions just given for examining wounds to detect lodgment of foreign bodies apply more particularly to such as penetrate the extremities, or extend superficially in other parts of the body; where a missile has entered any of the important cavities, search for it is not to be made, but the surgeon's attention is to be directed to matters of more vital importance to be hereafter noticed.

As soon as the site of lodgment of a ball or other foreign body is ascertained, as a general rule, it should be removed. If it be lying within reach from the wound of entrance, it should be extracted through this opening by means of some of the various instruments devised for the purpose. In case of a leaden bullet, Coxeter's Extractor, corresponding with Baron Percy's instrument for the same purpose, and consisting of a scoop for holding, and central pin for fixing, the bullet, has been found a very convenient appliance, from the comparatively limited space required for its action. Instruments of two blades, or scoops, with ordinary hinge action, dilate the track of the wound injuriously before a foreign body can be grasped by them; but when the blades are capable of being inserted separately, and then of being united, after the manner of midwifery forceps, this objection is obviated, and they are then very serviceable for removing small iron balls, fragments of shells, and similar hard projectiles.

The way to the removal of a bullet may often be smoothed by judiciously clearing away the fibres among which it is lodged, during the digital examination; and sometimes, by means of the finger in the wound, and external pressure of the surrounding parts, the projectile may be brought near to the aperture of entrance, so that its extraction is still further facilitated. Such foreign substances as pieces of cloth can usually be brought out by the finger alone, or by pressing them between the finger and a silver probe inserted for the purpose. Sometimes a long pair of dressing forceps, guided by the finger, is found serviceable for effecting this object. Caution must of course be used, in employing forceps in this way where the foreign substance is out of sight, and of such a quality that the soft tissues may be mistaken for it. It does not often happen that it is necessary to enlarge the openings of wounds to remove balls, although a certain amount of constriction of the skin may be expected from the addition of the instrument employed in the extraction; but if much resistance is offered to their passage out, it is better to divide the edges of the fascia and skin to the amount of enlargement required, than to use force. In removing fragments of shells, the fascia and skin have almost invariably to be divided, sometimes to a considerable extent.

In removing slugs, stones, and other irregularly-shaped bodies, the surgeon cannot be too guarded in arranging that the fragment is drawn away with its long axis in line with the track of the wound. By proper care in this respect, much injury to adjoining structures may be avoided. This rule specially applies to modern elongated bullets, some of which have a long diameter of an inch and a quarter or upwards, with a short diameter of only four-tenths of an inch; with a round bullet no attention is necessary as to its extraction in any particular direction.

When the foreign body has not completely perforated, but is felt to be lying near the surface of a part at some distance away from the wound of entrance, an incision must be made for its extraction. Before using the knife, the substance to be removed should be fixed *in situ*, by pressure on the surrounding parts. In the instance of a round ball, the incision through the skin and fascia should be carried beyond the length of its diameter; an addition of half a diameter is usually sufficient to admit of the easy extraction of the ball.

When cylindro-conoidal bullets lodge in one of the extremities in the manner described, it will very generally be found that the base of the bullet presents itself toward the surface, owing to its having made a partial revolution upon one of its short axes while traversing the limb, and an incision of proportionate length should be made for its removal.

If balls are impacted in bone, as occasionally happens in the spongy heads of some bones, in the bones of the pelvis, and, though rarely, in portions of the shafts of long bones, they should equally be removed. The fact is now fully established that, although in a few isolated cases balls remain lodged in bones without sensible inconvenience, in the majority the lodgment leads to such disease of the bony structure as to entail troublesome abscesses, and if it be in a bone of one of the extremities, eventually to necessitate amputation. If the bullet be superficially lodged, its removal can be effected by means of a steel elevator, of convenient size ; or, should this fail from the ball being too firmly impacted, a thin layer of the bone on one side of the ball may be gouged away, when a better purchase will be obtained for the elevator, and its action be thereby facilitated. If the impaction be deep and it be a leaden bullet, the 'tire-fond' screw, which is much used by French military surgeons, or Luer's sharp-pointed bullet-forceps which bite into and secure a most firm grasp of the object, will best accomplish the extraction. The lodgment of balls even in the cancellous apophyses of bones will not often occur without extensive fracture where rifle-balls strike with force, but will still happen when their momentum is much diminished.

Whatever reason there may be, however, for concluding that a ball or other foreign body has lodged in a wound, if, after a moderate amount of manual examination, and observations made in varied postures of the part of the body supposed to be implicated, after attention has been given to indications derived from the patient's sensations, effects of pressure upon or injury to nerves, and to all other circumstances which may lead to information—if after all these steps have been taken the site of the lodgment be not ascertained, the search should not be unreasonably persevered in to the distress of the patient. And even if the site of lodgment be ascertained, if the removal of the foreign body can only be effected by violence, or by severe and extensive incisions, or if there is danger of wounding important organs in trying to reach it, the attempts at extraction should not in ordinary cases be continued. In short, although immediate extraction of a bullet is the rule, it is not to be followed beyond reasonable limits or at all hazards. Either during the process of suppuration, by some accidental muscular contraction or by gradual approach toward the surface, its escape may be eventually effected without such risks; or, if of a favourable form, and if not in contact with nerve, bone, or other important organ, it may become encysted, and remain without causing either pain or mischief. John Hunter has recorded, in his treatise on gun-shot wounds, that the practice of searching after a ball, broken bones, or any other extraneous bodies, was then in a great measure given up from experience of the little harm caused by them when at rest and not in a vital part; and he himself advises, even when a ball can be felt beneath skin that is sound, that it should be let alone, chiefly on the ground that two wounds are more objectionable than one, and that the extent of inflamed surface is proportionably increased by incision. More extensive experience has shown, that not only is the risk of subsequent ill results greater in those cases where foreign bodies remain lodged than when they have been cut out, but also that the advantages of a second opening, for the escape of the necessary sloughs and discharges, greatly preponderate over the disadvantages connected with it as regards the additional extent of injured surface. The advantage also of the satisfaction to the mind of a patient from whom a ball has been removed must not be overlooked; for men suffering from gun-shot wounds are invariably rendered uneasy by a vague apprehension of danger, for some time after the injury, if the missile has remained undiscovered.

In the majority of gun-shot wounds, early care and attention will suffice to effect the removal of any foreign bodies lodged in them, and, as soon as this has been accomplished, whenever a wound has been accompanied with much laceration and disturbance of the parts involved in the injury, the next point to attend to is to readjust and secure the disjoined structures as nearly as possible in their normal relations to each other. The simplest means—strips of adhesive plaster, light pledgets of moist lint, a linen roller, favourable position of the limb or part of the body wounded—should be adopted for this purpose. Pressure, weight, and warmth should be avoided as much as possible in these applications, consistent with the end in view. It must not be forgotten, in thus bringing the parts together, that the purpose is not to obtain union by adhesion, which cannot under ordinary circumstances be looked for, but simply to prevent avoidable irritation and mal-position of parts, during the subsequent stages of cure by granulation and cicatrisation. In all gun-shot wounds, much discomfort to the patient is prevented by carefully sponging away all blood and clot from the surface adjoining the wound, and by adopting measures to prevent its spreading again in consequence of oozing. This can be readily done with the aid of a little warm water and proper management when the wound is first dressed, but can only be accomplished with considerable inconvenience after the thin clots have become hard and firmly adherent to the skin.

In simple penetrating wounds, and in lacerated wounds after the torn structures have been brought into proper apposition, the dressing usually employed in military practice is moistened lint. If clean water cannot be obtained, as sometimes happens in the field, or lint is scarce, a small piece of cotton or linen cloth dipped in oil and covered with oiled silk, and the application of a bandage afterwards, form the most convenient substitute. But water and lint being in abundance, the latter should be kept moist, either by the renewed application of water dropped upon it, or by preventing evaporation by covering it with oiled silk. The sensations of the patient may be consulted in the selection of either of these, and climate and temperature will be often found to determine the choice. In hot climates cold applications are the more grateful, and by checking the amount of inflammatory action and circumscribing its extent are usually the more advantageous. M. Velpeau, and other French surgeons, have strongly recommended the use of linseed-meal poultices, above all wet linen applications; they are almost abandoned in English practice. Charpie is still extensively employed in French military hospitals. M. Baudens and Dr. Stromeyer have strongly recommended the topical application of ice, placed in bladders; others, the continued irrigation of the wound with tepid water. These remedies, especially the latter, are very valuable in particular cases, but the means of applying them are rarely available in the military hospitals where gun-shot wounds are ordinarily treated in their early stages. In fixed hospitals they can be employed with facility, and with the best results.

When suppurative action has been fully established, the surgeon must be guided by the general rules applicable to all other suppurating wounds and sores. It will be evident on reflection that especial care is necessary to obviate the accumulation and burrowing of pus in bullet wounds, which are usually both deep and narrow, and in which the areolar connections of many different parts are opened by the projectile in its course. Extended abscesses, and sinuses, are not unfrequent results of want of sufficient caution in this regard. If much tumefaction of muscular tissues beneath fasciæ occurs, or abscesses form in them, free incisions should be at once made for their relief. In a wound where the communication between the apertures of entrance and exit is tolerably direct, occasional syringing with tepid water is soothing to the feelings of the patient, and is useful by removing discharges and any fibres of cloth which may be lying in the course of the wound. Weak astringent solutions are occasionally employed in a similar way after all excessive inflammation has subsided, with a view to improving the condition of the sore surface, and exciting a more vigorous action in the process of granulation. On the Continent the use of a watery solution of the perchloride of iron has been greatly extolled for this purpose. The permanganate of potash, or Condy's solution, has also been found to be a valuable adjunct in the dressing of gun-shot wounds, for the purpose of destroying the offensive odours which accompany the discharges from some of them. After the principal battles in the Italian campaign of 1859, and again in Mexico, carbolic acid, under the name of phenic acid, was employed for similar purposes in some of the French military hospitals. The observations which have now been made of the effects of this acid, when applied to wounds in such a manner as thoroughly to exclude the access of air in its ordinary condition, seem to show that it will not only equally well answer all the objects attained by the use of the permanganate of potash, but that it will accomplish many other results of an important nature, as regards military hospitals, considering the condition in which they are usually found to be under the circumstances of warfare. The undoubted property which this agent possesses of diminishing the amount of suppuration, its antiseptic powers, and particularly the important quality attributed to it of preventing the occurrence of erysipelas and hospital gangrene in wards appropriated to surgical cases, will make it of all others the most valuable remedial agent as a local dressing that can be employed, in military hospitals containing many patients with suppurating and sloughing gun-shot wounds.

Under all circumstances, the strictest attention to cleanliness, the regular and complete removal of all foul dressings, and free aëration of the wards, are essentially necessary, both for the comfort and general well-being of patients with gun-shot wounds, as well as to allow the granulating process of repair in the wounds to go on healthily and without interruption. It cannot be expected that without these hygienic requisites, the serious evils which result from the accumulation and dissemination of noxious effluvia, in places where many patients with sloughing and suppurating wounds are gathered together, can be averted by any amount of disinfecting or antiseptic agents. In tropical climates, and in field-hospitals in mild weather, where many wounded are congregated, flies propagate with wonderful rapidity, and the utmost care is necessary to prevent the deposit of ova and generation of larvæ in the openings of gun-shot wounds, especially while sloughs are in process of separation. Cloths dipped in weak solutions of creasote, lotions containing oil of turpentine and camphor, and other similar applications, have been employed to avert this repulsive complication of gun-shot wounds, when these insects have abounded in great numbers.

It was once the custom to enlarge the orifices of gun-shot wounds by incision; and sometimes not merely the openings, but also the walls of the tracks tunnelled by bullets. The opinions held by the older surgeons respecting the nature of these injuries, already briefly adverted to in the historical remarks on the subject, sufficiently explain their object in making these incisions, namely, to convert what they regarded as poisoned into simple wounds. Even so late as 1792, Baron Percy, in his *Manuel du Chirurgien d'Armée*, writes, 'The first indication of cure is to change the nature of the wound as nearly as possible into an incised one.' The treatment by incision continued even after the idea that gun-shot wounds were poisoned wounds had been exploded, the advocates for the practice arguing that it was necessary to obviate tension, and prevent strangulation of neighbouring tissues by tumefaction, on inflammation arising in the track of a projectile. This practice retained such a hold in France that French surgeons usually still consider it necessary to discuss the merits or otherwise of 'débridement' of gun-shot wounds; opinion among Continental surgeons, however, now appears to be almost universally opposed to the practice. English surgeons generally discarded it after the arguments urged by John Hunter against it, just about the same date as Baron Percy wrote, excepting only in cases where it is required to allow of the extraction of some extraneous body; to secure a wounded artery; to replace parts in their natural situation, as in protrusion of viscera in wounds of the abdomen; or, 'in short, when anything can be done to the part wounded, after the opening is made, for the present relief of the patient, or the future good arising from it.'

During the late war of the rebellion in the United States, Professor Chisholm of South Carolina introduced a plan of incising the orifices of gun-shot wounds with a different object from that of the practice of 'débridement.' He pared the edges of the wound in such a way as to prepare them for union by adhesion, and thus sought to convert the open into a subcutaneous wound. His plan, which was designated 'the new method of rapidly healing gun-shot wounds,' was tried to a limited extent in the British army in New Zealand during the recent Maori war, but was not attended with success.*

The constitutional treatment of a patient with an ordinary gun-shot wound, uncomplicated with injury to bone or structures of first importance, should be very simple. The avoidance of all irregularity in habits tending to excite febrile symptoms or to aggravate local inflammation, attention to the due performance of the excretory functions, and support of the general strength, are chiefly to be considered. Bleeding, with a view to prevent the access of inflammation in such cases, is now never practised, as formerly, by English surgeons. The diet should be nutritious, but not stimulating. A pure fresh atmosphere is a very important ingredient among the means of recovery. If from previous habits of the patient, or from circumstances to which he is unavoidably exposed, the local inflammation becomes aggravated, topical depletion by leeches, saline and antimonial medicines, with strict rest of the injured part, should be had recourse to, the extent being regulated by the circumstances of each case. In instances such as these, when the inflammation has become diffused, the purulent secretion seldom confines itself to the track of the wound, but is apt to extend among the areolar connections of the neighbouring muscles; and if the cure be protracted, attention will be necessary to prevent the formation of sinuses. If a tendency to stiffness or contractions is exhibited, attempts must be made to counteract it by passive motion and friction, with appropriate liniments; if œdema and debility remain in a limb after the wound is healed, the cold-water douche will be found to be one of the most efficient topical remedies. In French practice, the administration of a chalybeate tincture,* as a tonic, or diluted as an injection, in wounds threatening to assume an unhealthy character, is very highly praised. It is stated, that under the conjoined employment of this remedy internally and externally, in wounds of a pallid unhealthy aspect, accompanied by nervous irritability and symptoms of approaching pyæmia, the granulations have resumed a red and healthy appearance, and the general state of health has become rapidly favourable.

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* A report on this subject will be found at page 523 of vol. vii. of the *Army Medical Reports.* London, 1867.

Progress of cure.—Simple flesh-wounds from gun-shot usually heal in five or six weeks. In the course of the first day the part wounded becomes stiff, slightly swelled, tender, a slight inflammatory blush surrounds the apertures through which the missile has passed, and a slight serous exudation escapes from them. Suppuration commences on the third or fourth day, and in about ten days or a fortnight the sloughs are thrown off. Granulation now progresses, more or less quickly according to the health and vigour of the patient's constitution. The opening of exit is usually the first closed. When the wound is complicated with unfavourable circumstances, whether inducing in the patient a condition of asthenia, or leading to excess of inflammatory action, the progress of the cure may be extended over as many months, as, under favourable circumstances, weeks are occupied in the process.

GUN-SHOT WOUNDS IN SPECIAL REGIONS OF THE BODY.

The circumstances connected with wounds in particular situations of the body, or in particular organs, are in many respects common to injuries from other causes than gun-shot; and in the following remarks the attention is chiefly drawn to those leading peculiarities which constantly demand the consideration of the army surgeon, and which spring either from the nature of gun-projectiles, or from the conditions under which this branch of surgical practice has for the most part to be pursued.

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* Perchlorure de fer, 30 drops, two or three times daily as a tonic, and diluted with six parts of water as an injection.

Gun-shot Wounds of the Head.

No injuries met with in war require more earnest and careful observation, a more guarded prognosis, or more caution in their treatment than wounds of the head. The vital importance of the brain; the readiness with which violent concussions, as well as more obvious lesions, can be inflicted on it, indirectly as well as directly, by gun-shot projectiles; the varied symptoms which accompany the injuries to which this organ may be subjected; the difficulty which so frequently exists in tracing out their exact causes; the many complications which may arise in consequence of them; the sudden changes in condition of patients which not unfrequently occur without any previous warning;—all these are circumstances which will keep a prudent surgeon who has charge of these wounds continually on the alert while they remain under his care. Injuries of this class, the most slight in appearance at their onset, not unfrequently prove most grave as they proceed, from effusions, encephalitis and its consequences, or from plugging of the sinuses by coagula, leading to coma, paralysis, or pyæmia; and the converse sometimes holds good with injuries presenting at first the most threatening aspects, where due care is taken to avert these serious results. The gravity of the case may be modified by several circumstances:—by the part of the head struck, whether it be upon some of the thicker and stronger portions of the skull, upon parts where the diploetic structure is plentiful, or on parts thin and easily splintered; over the situation of the sinuses; parts closely adjoining the cerebrum; the degree of force possessed by the projectile; its shape; the angle at which it has struck; the age and condition of the patient; and some other matters already referred to in the general remarks on gun-shot wounds. Mr. Guthrie laid down as a rule that injuries of the head, of apparently equal extent, are more dangerous on the forehead than on the side or middle portion, and much less dangerous on the back part than on either of the foregoing; and that a fracture of the vertex is infinitely less important than one at the base of the cranium. When the injuries are caused by rifle-balls coming into collision with the head at a high rate of speed, however, these considerations respecting position are rarely of much avail, for the usual force of these projectiles is such that the injury is scarcely ever confined to the immediate neighbourhood of the part directly struck. When caused by bullets whose velocity has been in a great degree spent, or by small fragments of shell, the injuries may be localised, and the accident of situation then becomes a point to be considered in estimating the probable issue of any particular case.

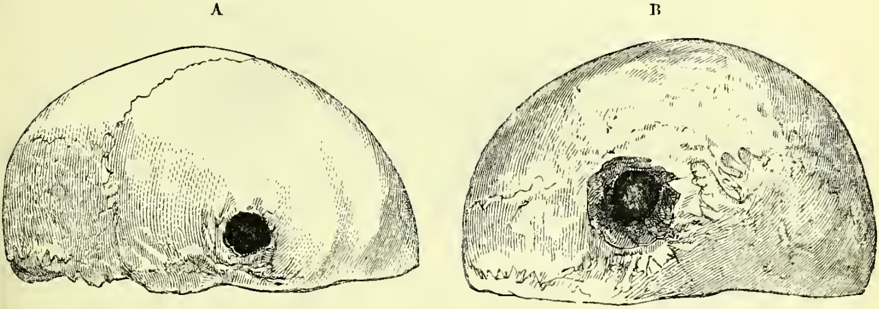
Perhaps the most striking early feature which first attracts the notice of the observer of gun-shot wounds of the head as they occur in field practice, if he has only been accustomed to seeing wounds of the head from violent blows as they are met with in civil life, is, in the majority of cases, the small amount of *evident* injury compared with the amount of *real* injury. A large proportion of the wounds of the upper and side parts of the head which are brought to civil hospitals, present extensive bruisings and lacerations, the scalp hanging down in flaps, the bone bared, and complications such as mutilation of the face and features, with much hæmorrhage, but after all with comparatively little mischief of a permanent nature to the encephalon. The majority of head wounds on a field of action, being caused by small projectiles, exhibit no such extensive disfigurements, and are accompanied with comparatively little bleeding; while not improbably the condition of a patient from the effects of such an injury is as grave as if his head had been beaten by repeated blows with a hammer or crushed by a carriage wheel. The experience of the civil surgeon leads him to entertain the idea of a speedily fatal issue only when the usual evidences of deep and extensive injury are obvious to sight; the experience of the military surgeon leads him always to hesitate in forming a prognosis, however limited a gun-shot injury may appear to be at first observation.

As regards more remote results, in a considerable proportion of the cases of direct wounds of the head which are presented in civil practice, the violence which has caused the injury is subject to the restorative powers of the structures injured: the inflammation which follows is of the plastic and reparative kind. On the other hand, in by far the greater number of cases which occur in military practice, the violence which has caused the injury, even though not of an immediately fatal nature, is in excess of the restorative powers of the structures directly injured; while the concussion and contusion which at the same time are inflicted on neighbouring tissues are also so severe as to cause the inflammation which follows to be of an unhealing character—to be productive of sloughing, diffused meningitis and encephalitis, the formation of deeply-seated abscesses, or of long-continued purulent and sanious discharges.

Of indirect injuries, fractures of the base or other parts of the cranium by counterstroke, such as are caused by falls from considerable heights, and which are of so serious a nature in civil hospital practice, comparatively few examples are met with in military field practice. This is only what might be expected from considering the nature of the projectiles and forces by which wounds of the head are produced in battle.

The appearances presented externally by the openings of entrance and exit in the cranium after a perforating wound of the head, in the one case by a round ball, and in the other by a conoidal rifle-ball, are shown in the following drawings.

Fig. 24.



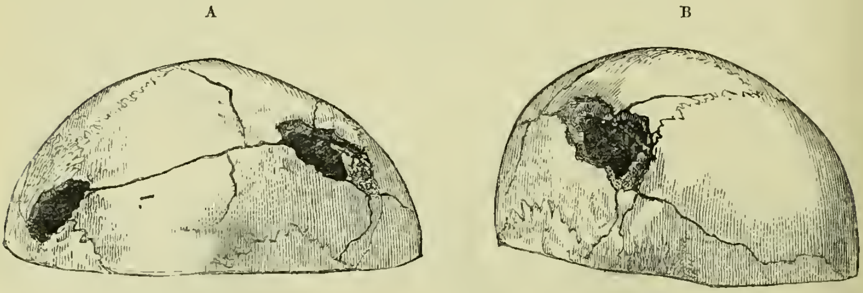
A. Calvarium showing the opening of entrance of a round pistol ball. (From a preparation in the Army Medical Department Museum at Netley.)

B. Calvarium showing the opening of exit of a round pistol ball. (From the same preparation as the adjoining sketch.)

Fig. 24 is copied from the calvarium of an officer who was killed by a large duelling pistol-ball. The regular defined opening of entrance in A, corresponding with the projectile itself in form and size, is well marked, as is also the larger and bevelled aspect of the wound of exit in B. The absence of fissures is worthy of note.

The next figure, No. 25, is copied from the calvarium of a soldier who was wounded in the head by a rifle-ball in the trenches before Sebastopol in 1855. The patient survived the injury eight hours. As in the former instance, the edges of the opening of entrance are sharp and defined, while that of exit is larger and more irregular. The bullet in this case struck the head obliquely, and hence the elongated form of the opening, closely approximating to the outline of the conoidal projectile in one of its longer diameters. The chief part of the bone carried from the entrance wound into the cranium was again carried out of the cranium through the exit wound with the bullet, for only a few small spiculæ were found inside the cranium after death. This fact no doubt influenced the size and shape of the aperture of exit. The fissure joining the two apertures, and the fissures radiating from the apertures themselves, indicate the great commotion to which the whole of the wounded side of the calvarium has been subjected. The greater amount of 'starring' at the wound of exit is probably in part due to diminished momentum in the projectile.

Fig. 25.



A. Calvarium showing the apertures of entrance and exit made by a rifle-ball. (From a preparation in the Army Medical Department Museum at Netley.)

B. The same calvarium. The wound of exit and the long fissures extending from it are shown in this view.

An important point in practice is that, when a bullet penetrates the cranium, the condition of the opening in the inner table differs from that in the external table, inasmuch as it is always larger, more jagged and irregular in outline, and usually exhibits several cracks proceeding from its margins. Sometimes segments of the inner table are completely detached from the neighbourhood of the wound of entrance. The extent to which these conditions may exist varies considerably in different cases, and cannot be diagnosed from any external appearances in the outer table.*

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* This particular subject has been examined very fully by W. F. Teevan, F.R.C.S., of the West London Hospital. *See* 'Experimental Enquiries into certain Wounds of the Skull,' &c., by him, in the *Brit. and For. Medico-Chirurgical Review,* for July 1864 and July 1865.

Classification.—Wounds of the head may be divided, for convenience of description, into wounds without fracture of bone; similar wounds complicated with fracture of the outer, inner, or of both tables, without marked pressure on the encephalon; wounds with fracture and marked depression; and, lastly, wounds with fracture and depression in which the projectile has lodged at the opening or has passed into the encephalon. All these varieties of wounds, except the last, may happen without the admission of air to the parts most seriously injured; for severe contusion of the bones of the cranium, and fracture, both with and without depression, occasionally occur without any open wound of the superficial investments.

Wounds of the head without fracture of bone.—These may consist of contusions without an open wound, or may be accompanied with an open wound.

Contusions of the integuments of the cranium rarely result from direct projectiles, but are frequently met with from those of the indirect kind. The force of a rifle-ball must be very nearly expended before striking the head to produce only an injury of this nature. When a soldier is brought to a surgeon with a history that he has been struck by a fragment of shell, a piece of stone from a parapet, or some unknown projectile, especially when the immediate force of the injury has been partly broken by the man's shako intervening, if no symptoms of compression exist and those of concussion are moderate or passing off, if on examination only ecchymosis of the scalp can be distinguished, the hope may be entertained that the injury is limited to the obvious contusion of the integuments. The absence of symptoms of compression, together with the history of the injury, must be the chief source of belief that no complication exists, but even these facts cannot be wholly relied upon for indicating that no fracture has been caused by the blow. The diagnosis of gun-shot injuries of this order, if the contusion be severe, must always contain elements of uncertainty.

But contusions of the head, though uncomplicated with fracture and apparently slight in nature, when they happen from gun-shot, are by no means injuries to be lightly regarded. The amount of bruising obvious to sight, and the degree of cerebral concussion, may have seemed trifling, and yet the remote consequences may be serious enough. Examples of this are frequently seen among military invalids. Soldiers who have been so little overcome by the effects of a wound presenting the symptoms of one of the kind under consideration, that they have been able to walk to a field-hospital and themselves to give an account of the injury they have sustained, will sometimes remain under treatment for months, and eventually have to be discharged from service. They may appear robust, their bodily functions may be regular, but without any physical cause obvious to surgical inspection they may still suffer from frequent headaches, occasional fits of nervousness and palpitation, disturbance of some of the special mental faculties, as memory, for example, susceptibility to cerebral derangement from slight sources of excitement, and capricious irritability of temper: and these symptoms may last for years if not for the whole period of life.

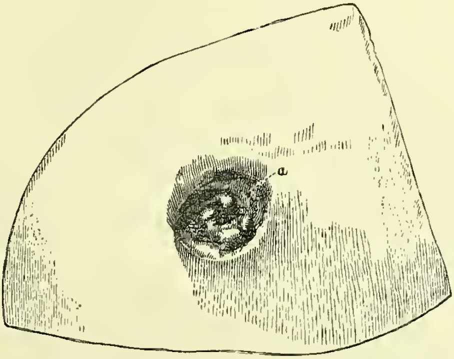
Lastly, these contused injuries without breach of continuity in the coverings or fracture of bone, are occasionally accompanied by so much mischief to the encephalon as to lead to a speedily fatal issue. The substance of the brain may be then found to have been torn by the violent movement to which it has been subjected; there may be extravasations of blood without obvious lesion of substance; or its texture may present only signs of congestion. Again, cases have been noted where soldiers have died immediately after such an injury as a stroke from a heavy fragment of shell in the head without fracture of cranium, and where no cerebral lesion has been perceptible to sight at the post-mortem examination. Perhaps in such cases the sudden destruction of life may be due to molecular changes throughout a great part of the nerve structure, or there may be lesion, though unappreciable, at some part of the brain from which nerves controlling actions essential to life take their origin. It has been argued that such cases are really cases of contusion of the brain, in consequence of the organ having been compressed and injured by momentary alteration in the shape of the skull, which, it has been alleged, can take place in consequence of the elasticity of the cranium.

Open wounds of the integuments of the cranium without fracture are usually inflicted by projectiles which are brought into contact with the head at a very acute angle, so that not only is bone not broken, but little direct injury to the brain or its membranes is inflicted, and the surgeon's attention need only be directed to the same considerations as must occur in any open contused wounds of the scalp from other causes than gun-shot. But serious cerebral concussion, and other lesions, such as denuding the bone of its periosteum, are occasionally met with in these accidents. In the former case, the usual stupor and other signs of concussion may be very evanescent, or may last for several days, disappearing gradually and wholly, or entailing subsequent evils at more or less remote periods. When the pericranium as well as the scalp is removed by a musket-ball, superficial as the injury may still seem, there must always be, not only a certain degree of injury and bruising to the bone from which it is torn, but also some laceration of the vessels which inosculate with the nutritive capillaries of the diploë, and through them of the vessels of the meninges with which they are connected. The injury to this vascular system almost invariably leads to necrosis of the portion of the skull from which the coverings are carried away; and sometimes, even when the pericranium is not torn off, sufficient injury is inflicted to lead to a like result. The death of bone is generally limited to a thin layer of the outer table, which in due time exfoliates, and cicatrisation follows. But after exfoliation has taken place, and the wound in the scalp is healed, liability to headache, tendency to giddiness, inability to wear a shako, or to bear exposure to a tropical sun, are frequent consequences which unfit the patient for performing military duty.

The injury which occasionally happens in these cases to the vessels ramifying between the inner surface of the cranium and the dura mater may entail serious results of other kinds. There may be rupture of a sinus leading to compression, or fatal results may ensue from inflammation and suppuration. The case of a young soldier in whom the longitudinal sinus was thus ruptured occurred to the writer. In this instance a rifle-ball had divided the scalp and pericranium about four inches in length obliquely across the skull, just anterior to the angle of the lambdoidal suture, the posterior end of the sagittal suture being exposed midway in the line of the wound. The patient vomited at the instant of the blow, and symptoms of compression, mixed with some of concussion, soon followed. He died eleven hours after the injury. At a post-mortem examination, the superior longitudinal sinus was found to be ruptured, and about four ounces of coagulated blood were lying on the brain. Two darkly-congested spots were observed in the cerebrum, one on each hemisphere, corresponding with the line of direction in which the ball had passed, and these, when cut into, presented the usual characters of ecchymoses. There was no fracture of bone. The case may be found detailed at some length in the *Lancet*, vol. i. 1855. When inflammation follows the superficial passage of a ball, whether terminating in resolution or leading to abscess, the symptoms will be similar to those of the same affections from other causes, such as are met with in civil practice, and no special considerations are involved in them. In like manner, the occurrence of erysipelas, and other complications to which such wounds of the scalp are liable, will be founded treated elsewhere. (See INJURIES OF THE HEAD.)

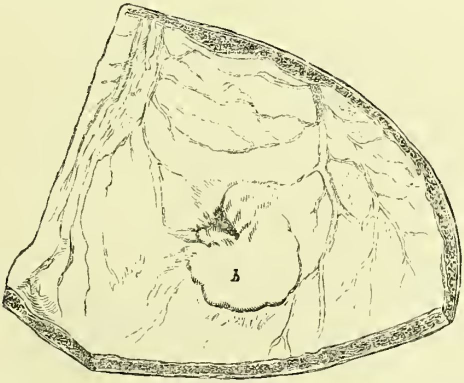
Wounds complicated with fracture, but without marked depression on the cerebrum.—These are very varied in their effects, and often apt to mislead the surgeon, from the absence of urgent symptoms in their early stages. When these accidents occur without an open lesion of the integument, and the fractures are of moderate extent, in consequence of their being almost necessarily accompanied with a great amount of subtegumentary ecchymosis, the diagnosis is rendered very difficult, and sometimes must remain without being established until a late stage of the case, or until death affords the opportunity of demonstration. Figures No. 26 and No. 27 represent an interesting example of this class of injury; they are drawn from a specimen (No. 2884) in the Army Medical Department at Netley Museum. The preparation, which consists of a portion of the left parietal bone exhibiting a healed fracture, was taken from a soldier of the 80th Regiment who received a severe contusion of the head from a round shot at the battle of Ferozeshah in 1845. When first surgically examined after the wound, there was found to be great tumefaction from ecchymosis, but there was no breach in the scalp, nor was there any marked disturbance of cerebral function. No fracture was detected. Suppuration and exfoliation of the outer table to a limited extent followed, after which the patient recovered, and returned to his duties as a soldier. In June 1851 the man died of dysentery at Dinapore. It was then discovered that there had been a fracture of the internal table. Its seat corresponded with the indentations which had been left after the exfoliations from the external table. The edges of the broken bone had become smoothed off, and were reunited to the old bone. Mr. Taylor, then surgeon of the 80th Regiment, who made the post-mortem inspection, has recorded that 'there was a slight depression in the cerebral substance and membranes of the brain opposite to the seat of fracture, and that this part of the brain presented a dark and vascular appearance, but there was no thickening of the membranes nor any traces of effused lymph.'

Fig. 26.



Portion of a parietal bone showing (*a*) depression after exfoliation of a small portion of the external table. The appearance at *a* is partly due to some adherent fibrous tissue which has been dried *in situ* in the preparation.

Fig. 27.



Interior view of the same segment of bone, showing at *b* a healed fracture of a portion of internal table.

If the cranial fracture, under similar circumstances of the integuments being unopened, be extensive and comminuted, the nature of the injury is obvious enough on first examination, but in such cases death is usually instantaneous. The case of an officer, who was thus killed by a round shot, is mentioned in Dr. Macleod's *Notes of the Crimean War*. The scalp was not cut, almost uninjured, but the skull was most extensively comminuted.

When, however, the integuments are laid open, and the existence of fracture can be detected by the finger, its occurrence is sufficient to show the force with which the projectile has struck the head, and should serve to indicate the mischief which the brain and its immediate coverings have not improbably sustained, whether cerebral symptoms are present to attract attention, or whether they exist only in a moderate degree, or are wholly absent.

The usual varieties of these gun-shot fractures without depression consist firstly, of simple furrowing of the outer table without injury to the inner; secondly, of fissure extending through both tables to a greater or less degree of length, or of several fissures in distinct lines; thirdly, of splitting of the internal table without fracture of the outer table; and fourthly, of comminution of both tables at the place the ball has struck in such small portions that they lie loosely on the dura mater without pressure or much alteration in the general outline of the cranial curve. The chief and only means in many cases of concluding that no depression upon the cerebrum has taken place, is the absence of the usual symptoms of compression; for it is well known that simple observation of the injury to the outer table, whether by sight or touch, will by no means necessarily lead to a knowledge of the amount of injury, or change of position, in the inner table. All that we have a right to conclude is that the brain is not pressed upon to such an extent as to interrupt its functions.

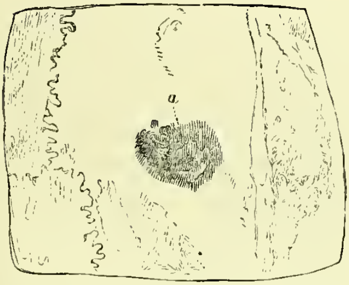
When simple removal of a portion of the outer surface of the skull has been caused by the passage of the ball or other missile, the wound will occasionally, but very rarely, heal without any untoward symptom. When such a wound terminates so favourably, a layer of the exposed surface of bone usually exfoliates and the granulating surface gradually becomes cicatrised. But such injuries may be, and, indeed, are generally followed by inflammation which extends through the diploëtic structure, and then not improbably abscess results between the internal table and dura mater; and further as a consequence of vascular supply through the diploë being stopped, and perhaps also partly from the effects of the original contusion, necrosis of the inner table itself may follow. Care must be taken not to mistake an injury of this sort, when it is first presented to notice, for a depressed fracture of both tables. This error in diagnosis is not unlikely to happen when the excavation or ploughing through the diploë effected by the projectile is deep and the cut edges of the outer table of bone bordering the excavation are rather sharp.

Fissured fractures, when the fissures extend through both tables of the skull, usually result from injuries by heavy projectiles. The passage of a ball may fracture and very slightly depress a portion of the outer table of the cranium without furrowing it, and then the line of fracture will very closely simulate fissured fracture extending through both tables, and the diagnosis between them be excessively doubtful. When fissured fracture exists, the distance to which it may be prolonged is often quite unindicated by any physical signs or general symptoms, and its extent is consequently very uncertain. A striking example of this fact was furnished in the instance of an ill-fated member of our own profession. Assistant-Surgeon Dr. ——, of the Bengal medical service, was wounded at Lucknow in 1857, by a fragment of shell, just as he was going under a gateway. The missile struck him at the back of the head and inflicted a lacerated wound near the upper part of the occiput. The unconsciousness which immediately resulted from the stroke of the projectile quickly and completely disappeared, and no marked cerebral symptoms followed. He was able to sit up in his bed, and freely talked about his own case and the differences of opinion among his brother officers respecting it. It was thought by some that fracture existed; but others, from the absence of symptoms and from no evidence of it being afforded from examination by the finger or probe, were of opinion that there was no fracture. The wound was inflicted just toward the termination of the siege, and a few days after its occurrence Dr. —— had to be removed with the garrison to the Dilcousha palace. This march seemed to disturb him considerably, and a day or so after his arrival there he died; extensive fissured fracture of the cranium was then discovered. Such fissures may occur at parts remote from the spot directly injured. In the case of a lieutenant of the 11th Hussars, who was apparently slightly wounded at Balaklava in the middle of the forehead by a piece of shell, a fissured fracture was found after death across the base of the skull, quite unconnected with the primary wound, and seemingly from *contre-coup*. Death resulted from inflammation and suppuration set up near this indirectly injured part after he had left the Crimea.

Fissured fracture of the inner table, without external evidence of the fracture, is a rare accident, but certain instances of it have been noted. Such a case occurred in the 55th Regiment in the Crimea. The soldier had a wound of the scalp along the upper edge of the right parietal bone. The ball in passing had denuded the bone; but there was no depression, nor appearance of fracture. The man walked to camp from the trenches without assistance, and there were no cerebral symptoms on his arrival at hospital. Five days afterwards there was general œdema of the scalp and right side of face, the wound became unhealthy, and slight paralysis of the left side was noticed. The next day hemiplegia was more marked, convulsion and coma followed, and he died on the thirteenth day after the injury. Pressure from a large clot of coagulum, and extensive inflammatory action, were the immediate causes of death; but a fissure, confined to the inner table, running in line with the course of the ball, was also discovered. A preparation of the calvarium in this case was presented by Dr. Cowan, 55th Regiment, to the Museum of the Army Medical Department, and is now in the collection at Netley. Dr. Demmé has recorded that he saw four cases which occurred during the campaign of 1859 in Italy, in which injury to the internal table was discovered by examination post mortem, when there was no apparent injury to the outer table, and in one of these, two inches square of the inner table had become detached. Eight examples of this interesting variety of cranial fracture, which occurred during the late War of the Rebellion in the United States, are preserved in the Army Medical Museum at Washington. One of these was very similar to the Crimean case detailed above. There were no signs of cerebral disturbance for seven days, when symptoms of compression supervened, and death followed. A fracture of the internal table of the left parietal bone was then discovered. The dura mater had been wounded by the sharp edge of the fissured bone, and abscess had occurred in the left cerebral hemisphere. The following drawings (Figs. 28, 29) illustrate another case in which a fragment of the inner table of the frontal bone, an inch and a half in length by half an inch broad, was completely detached, without there being any fracture of the outer table.

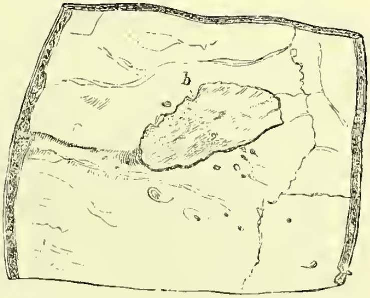
In a third case the probability of this kind of lesion having taken place was inferred during life, and trephining was employed. In this instance there was no headache nor disturbance of the cerebral faculties for more than a fortnight after the wound, which appeared at first to be only a lesion of the scalp and pericranium. When the trephine passed the outer table, pus escaped from the diploë, and a fracture of the inner table was then discovered. The patient died the following morning. An abscess had formed in the brain.

Fig. 28.



Exterior view of a portion of frontal bone. *a.* Outer table contused, but not fractured.*

Fig. 29.



Reversed view of the same specimen. *b.* Portion of inner table fractured and completely detached.*

The cases where comminution has resulted from the stroke or track of a ball across the skull, generally present less grave symptoms, and are less dangerous as to their results than those where a single fissured fracture, extending through both tables, exists. The comparatively less unfavourable character of these accidents may arise from the force of the ball happening to be expended locally on the part broken up into fragments, instead of being diffused more generally over the cranium, as probably always happens in the instance of fissured fracture. The more open condition of the wound may also be a source of the comparative immunity from fatal results. The small loose fragments can be removed; and if, what is most important, the dura mater be intact, the case, with proper care to prevent inflammatory action, may not improbably be attended with a favourable recovery.

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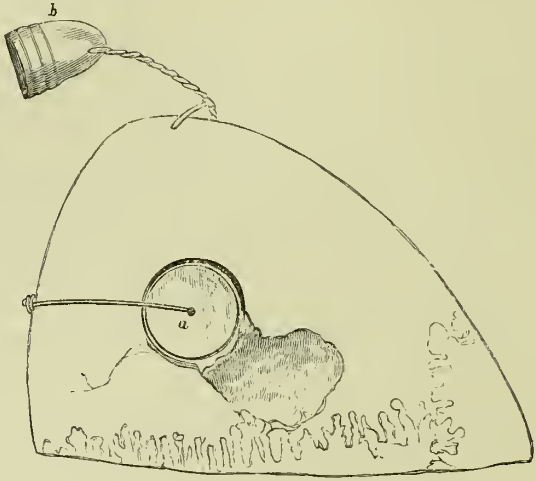
* Spec. No. 2313 in the United States Army Medical Museum. See *Catalogue of the Surgical Section*, p. 8.

Wounds complicated with fracture, and symptoms of depression on the cerebrum without lodgment of the projectile.—These gun-shot injuries are very serious, and the prognosis must always be unfavourable. They must not be judged of by comparison with cases of fracture with depression caused by such injuries as are usually met with in civil practice. The severe concussion of the whole osseous sphere by the stroke of the projectile, the bruising and injury to the bony texture immediately surrounding the spot against which it has directly impinged, as well as the contusion of the external soft parts, so that the wound cannot close by the adhesive process, constitute very important differences between gun-shot injuries on the one side, and others caused by instruments impelled solely by muscular force on the other. And as happens with the external parts, so also the injury to the brain within, and its investments, is proportionably greater in such injuries from gun-shot. The experience of the Crimean campaign shows, that when these injuries occurred in a severe form, they invariably proved fatal. Of seventy-six recorded cases treated in hospital, in which depression of bone only existed, without penetration or perforation of the cerebrum by the projectile, fifty-five proved fatal. In the twenty-one survivors, the amount of depression is stated in the surgical history of the campaign to have been slight; yet of these, twelve had to be invalided out of the service, and nine only were discharged to duty.

With depression and lodgment of the projectile, without or with penetration of the cerebrum.—It is obvious, that where a small projectile, having power not only to fracture but also to depress a portion of the cranium, becomes lodged, it will not usually be arrested in its progress at the opening it has made, but more frequently will pass on to a greater or less depth beyond it. It is, however, sometimes stopped at the seat of fracture. It may then be found to be entire, though flattened by the effects of the opposition it has met with from the strong and arched cranium, and by its violent collision with the fragments of the bone it has broken, and among which it is caught and retained; but more often is found to have been held back by other causes beside the simple influence of the resistance it has met with in causing the injury, and to be partially or wholly divided. The generally rounded form of the cranium causes it to be penetrated by small projectiles only comparatively rarely in a line directly perpendicular to the part struck. Usually the projectile and the cranial surface come into collision with each other obliquely, at angles varying, however, greatly in their degrees of acuteness. Hence it happens, when a missile striking the head slantingly has had momentum enough to fracture and to drive in, to a certain extent, the part of the cranium with which it is first carried into contact, its line of flight becomes deflected by the resistance it has met with into a still more acute angle with the curve of the cranium, after which, proceeding from a somewhat deeper level, its onward movement carries it against the jagged margin of the fixed portion of bone forming the upper boundary of the aperture at the seat of fracture. When this happens, the ball either becomes deeply grooved and retained, impaled, as it were; or a large part of it is retained, while a small portion is separated and carried onward: or it is completely divided into two parts by the sharp and hard edge of the broken bone. In this last event, the upper half of the ball may escape altogether, or be caught between the scalp and outer surface of the cranium; the inner half, in like manner, may lodge between the under surface of the cranium and dura mater, or, piercing the dura mater, may lodge in the cerebrum. Every campaign furnishes a series of examples of these accidents.

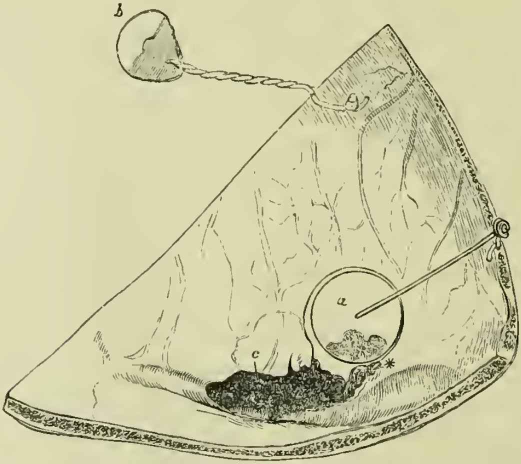
Figures No. 30 and No. 31 will serve to illustrate one of these accidents, which occurred in the writer's practice. The case presents several features of interest. The patient, a young soldier, was brought up from the trenches before Sebastopol in a state of coma. He had been struck on the head by a bullet. There was fissured fracture and slight depression, but no hole in the skull. Trephining was immediately performed, without any relief of symptoms following, and the patient died on the same day. At the post-mortem inspection, half the rifle-bullet which had inflicted the injury was found in the brain, just above the orbital plate of the frontal bone on the same side. The divided surface of the bullet presented as smooth a surface as if it had been cut by a sharp knife. In this instance there was no evidence during life of a foreign body having penetrated the skull; as soon as one half of the bullet had entered, the door through which it had forced admittance became closed; the other half of the bullet escaped altogether. Did the depressed portion of bone spring up and close the opening of entrance by its own resilience, or was this closure aided by the resistance and counter-movement of the brain from within?

FIG. 30.



External view of a segment of a parietal bone with depressed fracture. *a.* Portion of bone removed by trephine. *b.* Half of the rifle-ball found in the cerebrum.*

FIG. 31.



Interior view of the same preparation. *a.* Portion of bone removed by trephine. *b.* Half of the rifle-ball found in the cerebrum. *c.* Splintering of internal table extending to the situation of the longitudinal sinus.*

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* Spec. No. 2883 in the Army Medical Museum at Netley.

The usual result, however, when a depressed fracture is caused by a rifle bullet at ordinary speed, is that the whole of the projectile together with splinters of bone are carried through the membranes into the cerebral mass. Sometimes a ball, if not making its exit by a second opening in the cranium, will lodge at the point of the cerebral substance opposite to that of its place of entrance, but the course a projectile may follow within the cranium under such circumstances is altogether uncertain. The instance of a bullet passing into the cranium, through the cerebrum, and escaping by a counter-opening, only occurs when the projectile has struck at full speed and with immense force. It is almost needless to say that any wound of the cranium in which a projectile has effected a lodgment in the substance of the cerebrum, however near it may be to the surface, possesses characters of the utmost fatality. Of eighty-six cases in which either penetration or perforation of the cranium occurred in the Crimea, all died.

Rare instances have occurred where balls have lodged in the cerebrum, without giving rise to serious symptoms of danger for a long time. Such exceptional cases might lead to throwing surgeons off their guard in making a prognosis, from supposition that the ball by some accident had not lodged. The case of a soldier wounded in Canada by a ball in the posterior part of the side of the head is mentioned by Mr. Guthrie. The wound healed, and the man returned to duty; a year afterwards he got drunk, and died suddenly. The ball was found in a sac, lying in the corpus callosum. Another soldier wounded at Waterloo had a similar recovery, and also died after intoxication. The ball was found deeply lodged in a cyst in the posterior part of the brain. In the Museum at Netley there is part of a cranium which was perforated by a musket ball, also at Waterloo. The history states that the bullet penetrated and lodged, but that the patient became convalescent. 'He was attacked with apoplexy fifteen weeks after the wound, and died. The ball was found loose in the lateral ventricle, having shifted from its original position.' What the latter position was, is not recorded. An artillery soldier was wounded in the Crimea by a rifle-ball, which entered near the inner angle of the left superciliary ridge. The wound progressed without a bad symptom, until a month afterwards, when coma came on, and death shortly followed. The ball was found in a sac, in which pus also was contained, at the base of the left anterior lobe of the brain.

In the year 1861 the writer attended an officer whose history left little doubt that he was then suffering from the effects of a musket-ball lodged in the brain. He had received his wound before Delhi, in September 1857. The medical officers who attended him immediately after the injury, reported that a bullet had made an opening through the posterior and inferior portion of the left parietal bone, that the dura mater was penetrated, that brain substance had been forced out at the opening in the cranium, and that the ball had passed out of sight and was probably lodged deeply. The nature of the opening, which was covered over by fibrous investment and the scalp at the time I examined it, indicated the direct passage of the projectile; for it was regular, nearly circular in shape, and the edges of the bone around could be felt to be even and straight—not shelving as happens in a fracture from a ball striking obliquely. The opening was depressed when the brain was in ordinary action; but, under excitement, or on stooping, the depression became filled up by the brain from below. The symptoms at this time, three years and a half after the wound had been received, were: imperfect memory; imperfect power of vision, not to an extent to incapacitate him for ordinary work, but chiefly noticed on continued visual exertion, such as on trying to read much; occasional headache and dizziness; neuralgic pain about the muscles of the back of the neck; partial loss of sensation and of voluntary power in the arm and fingers on the side opposite to that of the wound, the right; and inability for any exertion or excitement leading to determination of blood to the head. This officer was, of course, unfit to serve in a hot climate, or to undertake any such active exertion as would be necessary in a campaign, but by living in the most abstemious manner, and by strict regimen, he was enabled to discharge certain home military duties until the year 1868. During the unusually hot summer of that year, a state of stupor came on, and gradually increased until he died. No post-mortem inspection was permitted.

Treatment.—One of the first lessons to learn as regards the treatment of a gunshot wound of the head is the propriety of abstaining from surgical interference when the case is first brought to the surgeon. When a soldier is rendered insensible by a severe injury to the head, the patient presents an appearance so nearly allied to that of approaching death, that an instinctive desire to do something with a view to arrest a fatal termination seizes upon those in whose charge the patient is placed. One may choose to administer stimulants, another to bleed, and each, if his treatment be carried into effect, may cause irreparable mischief to the wounded man.

All that the surgeon stationed at a first line of surgical assistance need do, when a soldier unconscious from such an injury is brought before him, is to ascertain that the chest and throat are rendered free from all constriction by his uniform, so that the centre of circulation, and the respiratory apparatus, may have the fullest opportunity of recovering from the shock to which they have been subjected; to warn the bearers that the patient is to be kept strictly in the horizontal position throughout the transportation to hospital, and to be carried with as little shaking as possible; to put them on their guard as to the not improbable occurrence of vomiting; and to order the man's great coat to be thrown over the lower extremities to keep up warmth and circulation in them as far as practicable. The man's knapsack, if he was carrying one, should not in this case be put under his head: the object is to keep the head level, so that the blood may flow to and from the brain with the least difficulty while the circulation is enfeebled. If a vessel of the scalp be bleeding, a small pad of lint and pressure against the skull by means of a bandage will generally suffice to stop it; not always, however, for it has happened to the writer not to be able to arrest the bleeding of a divided artery hanging patulous from among the torn and contused tissues, neither by pressure, nor by torsion, nor exposure to cold, and a ligature has had to be placed on both divided ends.

When the patient has reached the field hospital, the horizontal position being still maintained, an attendant should shave the hair from the head around the seat of injury, so that a careful examination may be made by the surgeon. As in all other gunshot wounds, the examination should be made as early as possible, and as soon as the surgeon has satisfied himself as to the nature of the wound, the patient should be kept quiet, that he may gradually recover from the state of concussion and collapse, in which he will still probably be found at the time of his arrival at the hospital.

It will be convenient to consider the treatment to be adopted in each of the varieties into which these wounds have been classified.

Wounds without fracture of bone.—Supposing that the effects of contusion of the scalp are alone exhibited, the application of cold water-dressing, cold affusion, or ice bladders, if they can be obtained, to the head, is the only local treatment required. Whatever may be the extent of ecchymosis, and whatever its form, whether it be beneath the tendon of the occipito-frontalis muscle or diffused beneath the skin, the swelling should on no account be incised ; an opening will take away all chance of the effused blood being absorbed. If the effusion be extensive, suppuration is not unlikely to occur under any circumstances, and then opening is unavoidable, but every effort should be made to prevent it at the onset. It is occasionally recommended by Continental surgeons to make strong pressure upon the protuberances caused under such circumstances, with a view to cause the dispersion of the blood in the cells of the neighbouring areolar tissue. A piece of thin metal, placed in a compress, the pressure being maintained by a tight bandage, is the plan sometimes adopted for the purpose. But considering the situation of the injury, this mode of treatment appears to be neither so scientific nor likely to be so generally useful, as moderate pressure with appropriate cooling remedies. The thick and voluminous bandaging occasionally placed around a patient's head, with the intention perhaps of keeping the wet lint which has been applied to the injured part in its place, is also very objectionable, because it tends rather to promote than to prevent suppuration. Such restraining bandages should always be of the simplest and lightest character. Nothing can be better for the purpose than the six-tailed head bandage, especially when it is made of fenestrated linen to ensure additional coolness.

The general treatment should be all directed to limiting the amount of reaction and preventing inflammatory action among the important structures in the immediate neighbourhood of the seat of injury. This applies to the general treatment of every wound of the head, however trivial and however severe; and most especially in cases where the injury has been caused by the stroke of a direct projectile. An active purgative should be administered. The utmost abstemiousness as regards diet and drinks should be enjoined. In no injuries is the importance of abstinence rendered so manifest by the ill consequences of its neglect, as in injuries of the head. Excitement and disturbance of all kinds should be avoided. If the injury be apparently a slight one, the Surgeon may find it very difficult to enforce the regimen here indicated; but, for some days at least, however urgent may be the appeals of the patient, he should by no means give his consent to the rules laid down being infringed. Apparently slight as the injury may be, a slight excess may quickly convert it into a serious one.

The same treatment, local and general, is applicable to cases in which the only difference is the existence of an open wound. When caused by small projectiles, these scalp wounds are usually furrowed wounds, scooped out, as it were, their whole length; but sometimes the bullet, after entering the scalp, travels along some distance between it and the cranium, and makes a tunnel-like passage between the two structures before effecting its exit. In this latter case, in addition to the other treatment, occasional syringing the passage beneath the scalp with tepid water is useful. It carries away sloughs or discharges, and often removes small hairs which have been driven in by the projectile and act as sources of irritation in the wound.

Wounds, with fracture, without marked depression.—There should be no difference in the early treatment, even if below the contused scalp, or if more obviously through an open wound, there be distinguished a fracture of bone. The rules for preventing all disturbance, both bodily and mental, will be more imperatively necessary than in the previous cases, on account of the greater amount of injury which has been manifestly effected, with the closer contiguity and more direct connection of the injured parts with the brain; but no operative interference should be resorted to. There are reasonable grounds for hopes, deduced from experience, that, notwithstanding a fracture may exist, recovery may ensue without any surgical interference being had recourse to beyond the local treatment already described. Prudence dictates that with this simple treatment the patient should be very carefully watched, so that symptoms of compression may be noted at their earliest onset. In a case of this order intercranial extravasations from lesions of blood-vessels may occur suddenly, or, if the reaction be excessive, inflammation may rapidly be induced, and then the necessity of further surgical interference will have to be considered without delay.

Wounds, with fracture, and marked depression.—The treatment of these wounds, in which there is not only a compound fracture but the broken bone is depressed upon the encephalon, requires more particular consideration. It involves the question of the propriety of trephining in any gun-shot wound, for if the operation is to be performed at all, it must be most called for in those cases where depression of bone is obvious, and the usual effects of compression upon the brain are equally manifest from its influence on the whole frame of the patient.

The importance of the question makes it advisable to take a brief survey of previous opinions concerning this operation and of the results of the experience recently gained respecting it.

Formerly, a gun-shot wound of the head was supposed to be in itself a sufficient indication for the use of the trephine; indeed, even where no fracture was caused, an opening was recommended not many years ago by some surgeons to be made in the cranium, to meet symptoms which might be expected to result after such an injury as a severe contusion from a musket-ball. Such preventive trephining has been proved to be useless, as well as dangerous, and is universally acknowledged not to be an admissible operation. The majority of English military surgeons after the period of the Peninsular war limited the use of the trephine to cases where one of the three following conditions was supposed to exist: first, where depressed bone was causing interruption of cerebral function; second, where fractured bone had penetrated the cerebral substance; and third where an abscess had formed within reach, and was capable of evacuation. The tendency of the most recent experience in Europe, i.e. within the last fourteen or fifteen years, has been to confine the practice of trephining within still narrower limits than those just mentioned, particularly as regards the first class of cases, in which the interruption of cerebral function appears to be caused by the pressure of depressed bone; and when the very great difficulty of making accurate diagnosis in these cases is considered,—whether as to the distinguishing signs of compression; the precise seat of its cause, if the compression exist; the space over which this cause, when ascertained, may extend; its persistent or temporary character; the impossibility of estimating the amount of injury done to the internal table by a musket-ball from the external characters of the fracture; complications as regards deeper injury in the cerebrum; and certain dangers connected with the operation itself,—it hardly seems to be a matter of wonder that this tendency should exist. Besides, the numerous cases which have now been noted where bone has evidently been depressed, but the brain has accommodated itself to the pressure without serious disability being caused, or where compression from effusion has been removed by absorption under proper constitutional treatment, are farther causes of hesitation in respect to trephining. In the *Surgical Report of the Crimean Campaign*, it is stated that the trephine was only successfully applied in four cases during the whole war. There were three other cases of recovery after elevation of depressed bone, in two of those the fragments being raised by an elevator, in the remaining one by the aid of Hey's saw. Out of these seven cases the dura mater was known to have been uninjured in four: in one it was torn and a portion of brain protruded; in the other two its condition was not recorded. In not one of these cases, as far as known, did the injury follow such a violent cause as the stroke of a rifle-ball. Five were caused by fragments of shell, one by the explosion of a magazine : the cause of the seventh injury is not stated. When to the risks already mentioned above, the fact is added that but seven survivals occurred after forcible elevation of depressed fractured bone, four of them only by trephining, in the British army during the whole Crimean campaign; that these took place after injuries from projectiles of comparatively low force and velocity; and that in the majority of the cases the dura mater had not been penetrated; the limited value of trephining in gun-shot wounds of the cranium seems to be strongly borne out by the experience of that war. In the French report, by Dr. Scrive, it is stated that trephining was, for the most part, fatal in its results in the French army. In siege-operations, the experience as regards wounds of the head is always very extensive, the lower parts of the body being so much more protected in the trenches. According to Dr. Scrive's returns, one of every three men killed in the trenches before Sebastopol, and one in every 3·4 wounded, was injured in this region. In the English returns, wounds of the head and face in the men are shown as 19·3 per cent.; in the officers, as 15 per cent.; but this is of the total wounded in the field as well as in the trenches.

The experienced German surgeon, Dr. Stromeyer, who in the early part of his professional career advocated trephining in complicated fractures of the skull, states in his *Principles of Military Surgery*, that he has been led to abandon the practice. He has recorded that after the battle of Kolding, in Schleswig, in 1849, there were eight gun-shot fractures of the skull, with depression, and more or less cerebral symptoms. In all these, with one exception, the detachment of the fractures was left to nature, and all recovered. The exception was that of one patient, from whom some fragments were removed on the seventh day, and he was placed in such considerable danger by the treatment, that Dr. Stromeyer resolved never to adopt it again. In the following year in Schleswig, two young surgeons came under Dr. Stromeyer's care with gun-shot wounds of the head, accompanied by deep depression; they were both treated without trephining, and both recovered. Throughout the three campaigns of the Schleswig-Holstein war, Dr. Stromeyer records there was only one case of trephining which gave a favourable result. Of eight cases of fracture of the cranium, with displacement of both tables, recorded by Dr. Williamson, among men who were wounded during the Sepoy mutiny in India and who subsequently arrived at Chatham, none had been trephined. In all these there was a depressed cicatrix, the wound having contracted and become closed by a strong fibrous investment. In one case—a wound by a musket-ball in the centre of the forehead—the ball was supposed to be still lodged within the skull. No soldier reached Chatham from India on whom the operation of trephining had been performed. We are not yet aware of the total experience in regard to the practice of trephining during the Italian campaign of 1859, or in the German war of 1866. It appears that in the former war the results of the observations in the Crimea by the French and Sardinian surgeons, and the latest German experience, led to the operation being very rarely resorted to in any one of the three armies engaged. But the experience gained during the late war in the United States, so far as it has been published, has a tendency to unsettle our notions on the subject again. The Surgeon-General's circular issued in 1865, containing *Reports on the Extent and Nature of the materials available for the preparation of a Medical and Surgical History of the Rebellion*, states that out of 107 terminated cases in which the operation of trephining was employed, sixty died and forty-seven recovered; a ratio of nearly forty-four per cent. of recoveries. In 114 cases fragments of bone or of foreign substances were removed by the elevator or forceps, and of these sixty-one died and fifty-three recovered—a ratio of more than forty-six per cent. of recoveries. But the report further states that 'the data are not sufficiently complete to admit of fair comparative analysis; still it is difficult to avoid the impression that a larger measure of success has attended this operation in the late war than the previous experience of military surgeons would have led us to anticipate.' It is evident before conclusions can be drawn from the American statistics that the nature of the cases in which the trephine was employed should be known,—in how many the dura mater was opened, and how many not,—and other such circumstances affecting the results of gun-shot wounds of the head. In European military practice the experience of recent years would cause the trephine to be employed only in cases which were otherwise hopeless; perhaps the American surgeons may have applied it with less hesitation in ordinary cases of depressed fracture. At any rate, as the report itself indicates, deductions regarding the effect of this treatment in the United States must be withheld until all the experience has been gathered together, and the medical and surgical history, which is still in progress, of the whole war, is complete.

Military experience in Europe during the present century has made it as difficult to understand the frequent successful results of trepanning by the older civil surgeons, as to find a justification for the use of the operation in such slight cases as those in which they often performed it. The dura mater must have been unopened in most of the cases. Probably also the issues were so successful because the patients laboured under little else than the effects of the operation itself, while, as we well know, very fatal mischief usually exists in addition in those instances in which the operation is resorted to by military surgeons for accidents from gun-shot. While showing the ill results of operative interference, an occurrence, quoted by Sir G. Ballinghall, is worth mentioning, as it particularly illustrates the favourable results of abstaining from trephining in some cases. After the battle of Talavera, a hospital which had been established in the town had to be suddenly abandoned, and an order was given for all the wounded who could march to leave it. There was no time for selection, and among those who marched were twelve or fourteen men with wounds of the head, in which the cranium was implicated, four or five having both tables fractured, and two having the globe of one eye destroyed, along with fracture of the os frontis. All these men recovered, though they were sixteen days on the march, harassed and exposed to a burning sun, and had no other application than water-dressing. In the Netley Museum are several preparations, showing extensive depressed fracture of the inner table of the skull taken from patients who had recovered without trephining, and who died years afterwards from other causes. One only, however, of these specimens has a clear history that the fracture resulted from gun-shot. In all these cases the edges of the depressed portions of bone had become smooth, and united by new osseous matter, and the cerebrum must have accommodated itself to the new form of the inner cranial surface.

With regard to those wounds in which there is not only a depressed fracture but the projectile has passed into the brain-substance, trephining can scarcely ever be of any avail. Two or three instances are recorded in which the course of a ball has been traced from the site of entrance across the brain, and trephining resorted to for its extraction with success; but there are also many others in which the mere operation of the extraction of a foreign body has apparently led to the immediate occurrence of fatal results. Moreover, splinters of bone are almost always carried into the brain when balls penetrate its substance, and these may elude observation; or the ball itself may be divided and enter the brain in different directions, when the operation of trephining can only be an addition to the original injury, without any probable advantage. These are all circumstances to be considered in estimating the propriety of trephining in any particular case.

It is only right to wait until the recent experience in the United States is more fully elucidated; but, until that is before us, the following seem to be the rules of practice regarding this operation in gun-shot injuries which modern European experience tends to inculcate. When irregular edges, points, or pieces of bone, or foreign substances, are forced down and evidently penetrate—not merely press upon—the cerebral substance, or where abscess manifestly exists in any known site, and relief cannot be afforded by simpler means at the wound itself, trephining is a proper operation to be resorted to for effecting the necessary relief; but in all other cases harm will probably be avoided by abstaining from trephining, while benefit will be effected by simply resorting to long-continued constitutional treatment, viz. all the means necessary for controlling and preventing the diffusion of inflammation over the surface of the brain and its membranes; the most careful regimen, very spare diet, strict rest and quiet, the use of antimonials, occasional purgatives, cold applications locally, so applied as to exclude the air as much as possible from the wound, and perhaps depletion by venesection in case of inflammatory symptoms arising. Similar remarks will apply when the case is one of lodgment of a projectile within the brain; if the site of its lodgment is obvious, it should be removed with as little disturbance as possible, but trephining for its extraction when the place of lodgment is not definitely known, but the projectile is only supposed by inference to be lodging in a particular spot beneath the cranium, is an unwarrantable operation.*

Gun-shot Wounds of the Spine.

Gun-shot wounds of the spine are closely associated with similar injuries of the head. In both classes, corresponding considerations must be entertained by the surgeon in reference to the important nerve-structures, with their membranes, which are likely to be involved in the injury to their osseous envelope; in both, the effects of concussion, compression, laceration of substance, or subsequent inflammatory action, chiefly attract attention. As met with in warfare, the injuries of this region when accompanied with fracture, almost always, sooner or later, entail fatal results; when recovery does take place, the fracture has usually been confined to one of the apophyses of a vertebra, generally the spinous, and has been the result of the stroke of a bullet or other small projectile. Concussion of the spinal column, leading to paralysis more or less persistent, is not unusually occasioned by fragments of shell, or large projectiles of the indirect kind; but in these cases the accidents are mostly accompanied by extensive lesions of the neighbouring structures. Wounds of the spine from heavy direct projectiles, such as cannon-shot, being almost without exception immediately fatal, are not distinguished in the surgical returns; they only appear in the general list of killed in action.

In the *Surgical History of the Crimean Campaign*, thirty-two cases are noted in which vertebræ were fractured, ten being without apparent lesion of the spinal cord, and twenty-two with evident lesion. Of these, twenty-eight died; and four, in which the fractures were confined to the processes of the vertebræ, survived to be invalided. Dr. Chenu's returns show that out of 194 fractures of bones of the vertebral column in the French army caused by bullets or shell, 181 men died, 11 survived to be pensioned, and 2 returned to duty. In the two latter instances the sacrum had been fractured. Six men only, who had been wounded in the vertebral column during the Sepoy mutiny in India, arrived at Chatham. In all, the wounds were the results of musket-balls. Two were wounds of the sacrum; in the remainder, the portions of the vertebræ fractured were the spinous processes. In the Circular issued in 1865 from the Surgeon-General's office at Washington, it is stated that of 187 recorded cases of gun-shot fracture of the vertebræ, all but 7 proved fatal. Six of these were fractures of the spinous or transverse processes; the seventh was one in which a musket-ball fractured the spinous process of the fourth lumbar vertebra and penetrated the canal, but was extracted with the fragments of bone. In one fatal case in the Crimea, the ball passed through the spine rather below the first dorsal vertebra, leading to complete loss of sensation and voluntary motion below the seat of injury, and death on the sixteenth day afterwards; in another, the rifle-bullet entered the right side of the second lumbar vertebra, traversed the spinal canal at that part, and lodged in the body of the bone. In this latter case, violent pain was complained of in the lower extremities, shooting along the groins. The patient was paraplegic, and death ensued thirty-three hours after admission. In another fatal case, a rifle-bullet passed through the right cheek, and lodged near the base of the skull. There was no paralysis, but delirium and coma supervened, and the patient died five days after receiving the wound. The bullet was found after death, lying just below the basilar process, and a large piece of the atlas was broken off and almost detached. The spinal cord did not appear to have been primarily injured; but acute inflammation had been set up, and had extended to the membranes of the brain. There is a preparation in the Museum at Fort Pitt, which shows a gun-shot fracture both of the atlas and axis, without lodgment of the ball. The patient survived thirty days. It is curious that, in a case which was under the care of the writer in the Crimea, where a rifle-ball passed through the right loin, entered the spinal canal between the third and fourth lumbar vertebræ, breaking the laminæ, passed upwards within the column, between it and the cord, and made its exit through the left intervertebral foramen between the second and third vertebræ, as shown after death four years afterwards, no paralysis occurred at the time of the injury, nor subsequently, nor was any evidence afforded at the post-mortem inspection of thecal inflammation having been excited (see *Guy's Hospital Reports*, vol. v. 1859).

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* A very elaborate essay, entitled, *Étude sur la trépanation du crâne dans les lésions traumatiques de la tête,* par M. Hippolyte Baron Larrey (4to, pp. 123, Paris, 1869), which has appeared since the above was in type, may be consulted for further information on this subject.

In injuries of the vertebral column and spinal cord occurring in military practice, the mischief is usually so complicated and extensive, and the medulla itself so bruised, that the cases must be very rare indeed in which the operation of trephining, if justifiable in any case, can offer the slightest prospect of benefit. M. Baudens extracted by means of an elevator, a ball which had lodged in the eleventh dorsal vertebra, and was causing compression with complete paraplegia. The paralysis disappeared immediately after the extraction of the bullet; but tetanus came on four days afterwards, and proved speedily fatal.

GUN-SHOT WOUNDS OF THE FACE.

Wounds of the face from musket-shot, grape, and small fragments of shell are usually more distressing from the deformity they occasion than dangerous to life. Out of 573 cases of face-wounds registered in the Crimea among the British troops, only 14 died. No fatal case occurred among the officers. The proportion in the French army was larger. Dr. Chenu's returns show that out of 1,747 wounds involving the face and eyes, from gun-shot, 287 died. The Washington Circular before mentioned states that of 4,167 gun-shot wounds of the face, there were 1,579 fractures of the facial bones, and 2,588 flesh wounds; and that of the former, 891 recovered, 107 died, while the terminations of 581 cases were still to be ascertained. The absence of vital organs; the numerous natural divisions among the bones, and their comparatively soft structure, causing them to be less liable to extensive splitting; the copious vascular reticulation and supply rendering necrosis so much less likely, and repair so much easier than in other bones; the limited amount of space occupied by the osseous structure between their respective periosteal investments; and the opportunities from the number of cavities and passages connected with this region for the escape of discharges; are all causes of the comparatively favourable results of wounds in this as regards wounds in other regions. On the other hand, the vascularity of this region leads to danger both of primary, and especially secondary, hæmorrhage,—a circumstance which in all deep wounds of the face must be looked for as a not improbable complication. Lodgment of projectiles in some of the cavities of this region are not unfrequent accidents. The other complications of these gunshot wounds are lesions of the organs of special sense; of parts concerned in mastication, deglutition, and articulation; injury to the base of the skull; paralysis from injury to nerves; wounds of glands or their ducts, or of the lachrymal apparatus; but it is scarcely necessary to do more than allude to these lesions, as the considerations connected with their treatment will be found elsewhere.

Wounds from cannon-shot occasionally illustrate what horrible and extensive injuries may be borne in this region without life being at once extinguished. They are the more distressing because the patient lives conscious of his sufferings without possibility of surgical alleviation. The case of an officer of Zouaves, wounded in the Crimea, is recorded, who had his whole face and lower jaw carried away by a ball, the eyes and tongue included, so that there remained only the cranium, supported by the spine and neck. This unfortunate being lived twenty hours after the injury, breathing by the laryngeal opening at the pharynx, while his gestures left no doubt that he was conscious of his condition. Mr. Guthrie has recorded a similar case which occurred in an officer during the assault of Badajos. This patient suffered distressingly from want of water to moisten his throat, but could not swallow when some was brought. One eye was left hanging in the orbit, the floor of which was destroyed, and this enabled him to write thanks for attention paid him. He did not die till the second night after the injury.

In the treatment of gun-shot wounds of the face where the bones are much separated and displaced, the surgeon should always retain and re-adjust as many of the broken portions as possible. It is often surprising how small connexions with neighbouring soft parts will suffice to maintain vitality, and lead to restored union in this region. A case which occurred to the writer in August 1855, in a private of the 19th Regiment, is detailed in the *Lancet*, p. 436, of that year. The wound was caused by a fragment of shell. The right half of the arch of the palate was jammed in and fixed at right angles to the other half, and the upper maxillary bone was so shattered that it was scarcely possible to note the directions of the lines of fracture. The lower maxilla was broken in three places, and there was extensive laceration of the soft parts. Great difficulty was met with at first in unlocking the parts of the palate which had been driven into each other, and, when they were separated, the right half hung down loosely in the mouth; yet favourable union was obtained between all these fractures, the broken portions being adjusted so that the man recovered with both the upper and lower maxillæ consolidated in their normal relations to each other. No teeth had been driven out of their sockets, and they were very useful as points of support in the steps taken to procure coaptation of the disunited fragments.

Gun-shot Wounds of the Neck.

Gun-shot wounds of this region do not appear to be so fatal as might be anticipated from the large vessels and important canals leading to the thorax and abdomen, which at first sight appear to be so exposed and unprotected. Out of 147 cases of gunshot wounds of the neck admitted into the English hospitals in the Crimea, there were only 6 deaths—a mortality of 4·08 per cent. The mortality in the French army was much greater. Dr. Chenu's returns show that out of 385 patients with gun-shot wounds of the neck in the French ambulances, 101 died, —a mortality of 26·2 per cent. It is difficult to explain such a different result. The Circular from the Surgeon-General's office at Washington, states that of 1,329 cases of gun-shot wounds of the neck entered on the records, the ultimate results of 546 only had been ascertained, and that in these the mortality was 14 per cent. In no region are so many examples offered of large vessels meeting, but escaping from balls in their passage, as in this; because the cause which operates elsewhere—ready mobility among long and yielding structures—exists in a greater degree in the neck than in any other part. Where the large vessels happen to be divided, death must follow almost immediately.

Superficial wounds of the neck offer no peculiarities. The larynx and trachea being the organs most prominent, and most frequently injured, are those which chiefly attract the surgeon's notice in warfare; but a consideration of the anatomical structure will at once show what numerous other complications, whether from direct injury or consequent inflammation, projectiles are likely to cause when they are driven deeply into, or perforate, this region.

A brief abstract of some wounds of the neck, which occurred during the Crimean campaign, will serve to exhibit the leading symptoms connected with them when the larynx, or larynx and œsophagus, are involved.

In the surgical history of the war, it is stated that only three wounds of the neck, other than simple flesh-wounds, occurred among the officers from the commencement to the end of the war; of which two proved fatal, and one led to invaliding. In that number, however, is not included the case of an officer, Lieut. M., of the 19th Regiment, who came under the care of the writer. In this instance the neck was completely traversed, the œsophagus perforated from side to side, and the larynx injured. After the shock had subsided, the leading symptoms were aphonia, dysphagia, numbness of one arm, œdema and stiffness of the neck, distressing accumulation of mucus about the fauces, and slight pyrexia. Recovery progressed favourably, and on the twenty-second day after the injury both external wounds in the neck were healed, and the two in the œsophagus appeared to be closed also. The patient referred to, still suffers from a certain amount of aphonia. It was not enough to prevent him from performing his duties as a captain, but the want of sufficient power of voice disabled him for a more extensive command and ultimately caused him to leave the army. Another of these cases, in which emphysema of the neck, œdema of the glottis, great dyspnœa, and threatened suffocation gradually supervened in a superficial gun-shot wound of the neck with fracture of the thyroid cartilage, was treated by Assistant-Surgeon Cowan, 55th Regiment, who performed tracheotomy, and thereby saved the patient's life. In another the ball passed through the thyro-hyoid membrane, fractured the thyroid cartilage, and tore the lining membrane of the glottis. Tracheotomy was performed on the day after the injury without benefit, and the patient died. Liquids could not be prevented from passing into the trachea through the wound made by the projectile. In the case of a private of the 97th Regiment a bullet entered at the pomum Adami, and passed out by the anterior edge of the right sterno-mastoid muscle. Loss of voice, frequent cough, bloody sputa, slight emphysema at the wound of entrance, and nausea, were the leading symptoms. When the man attempted to drink, some of the fluid escaped by the wound of exit. After five days this occurrence ceased; and after the twelfth day, air no longer passed out of the wound of entrance. Both wounds gradually healed; but aphonia—the voice being reduced to a whisper—existed when the man left the regimental hospital. A soldier of the Rifle Brigade, under the care of Deputy Inspector-General Fraser, C.B., then surgeon of the battalion, had been shot through the trachea, and respiration was for some time carried on by the wound; gradually, however, it completely healed, and a favourable recovery ensued. Another interesting case occurred in a soldier of the same battalion, at the last assault of the Redan. A rifle-ball entered this man's neck at the lower part of the left sterno-mastoid muscle, passed across under the skin, wounding the anterior surface of the trachea, severed some fibres of the right sterno-mastoid, and effected its exit. The man was wounded at the same time by two other rifle-balls, both flesh-wounds, one through the left fore-arm, the other through the upper part of the right thigh; while a shell exploding near him, caused his left eye to be penetrated with particles of stone and earth. Vision was lost; but in other respects, excepting a little lameness from the wound in the thigh, he was discharged cured, after fifty-six days' hospital treatment.

The liability to concussion of the cervical portion of the vertebral column, and to injury of the deep cervical and other nerves, must not be overlooked. Wounds of the neck are often accompanied by more or less loss of power in one of the upper extremities; and more extensive paralysis occasionally succeeds, although there was no primary evidence of the spine being implicated in the injury.

Gun-shot Wounds of the Chest.

These always form a large proportion of the injuries from warfare, both in the open field, and more especially in sieges, where the upper part of the body is chiefly exposed. Dr. Scrive's returns show that the proportion of chest to other wounds was 1 in 12 in the trenches, and 1 in 20 in ordinary engagements. In the British forces they are returned as 1 in 10 among the officers during the whole war, and nearly 1 in 17 among the men, from April 1, 1855, to the end of the war. The ample space occupied by the chest and the exposed surface it presents as a target towards the enemy, would lead to the anticipation that wounds of this region would be very numerous in warfare. The grave accidents which are not unlikely to follow the severer forms of superficial gun-shot injuries of the chest, although the pleural cavities may remain unopened; the serious complications which are induced when the cavity of the chest is penetrated; together with the dangerous consequences of wounds of its chief viscera—the heart, great vessels, and lungs—cause the proportionate mortality to be very great. The British returns show that among the officers who came under hospital treatment for chest-wounds of all kinds, wounds of the chest-walls, as well as of the cavity enclosed by them, $31\frac{1}{2}$ per cent. and among the men $28{\cdot}\frac{1}{10}$ per cent. died. Dr. Chenu's returns show that in the French army, out of 2,506 chest-wounds, penetrating and non-penetrating, there were 817 deaths, or $32\frac{6}{10}$ per cent. Out of 935 survivors among soldiers of the Royal army wounded in the Sepoy mutiny of 1857–58 who were invalided home to England, the number invalided from the effects of wounds of the chest, all kinds included, was only 36. In many instances soldiers wounded in this region do not live long enough to come under surgical treatment, but die on the field of action either from penetration of the heart, hæmorrhage, suffocation, or shock; and the proportion of men with fatal chest-wounds returned as 'killed in action,' or as 'died under treatment,' will constantly vary according to circumstances connected with the nature of the military operations, and the opportunities of early removal from the field to the field-hospitals.

Gun-shot wounds of the chest may conveniently be divided for study into two classes, viz. *non-penetrating* and *penetrating*. NON-PENETRATING wounds become subdivided into simple contused wounds of the soft parietes; contused and lacerated wounds; similar wounds accompanied with injury to bones or cartilage; and lastly, those complicated with lesion of some of the contents of the chest, the pleura remaining unopened, or, if the pleura be opened, without any superficial wound of the integuments. In none of these—and this is their important distinction—is there any communication between the air external to the parietes, and the serous cavities of the chest. PENETRATING wounds may exist without wound, or with wounds, of one or more of the viscera of this cavity. Among the more serious complications with which the latter may be accompanied, is the lodgment of the projectile or other foreign bodies, or of fragments of bone, within the chest. As wounds of the heart and great vessels are almost invariably at once fatal, and as the organs of respiration occupy the greater part of the cavity of this region, it is with reference to the latter that the treatment of chest-wounds is chiefly concerned.

Non-penetrating wounds.—This division of gun-shot wounds includes a considerable proportion of recoveries. Out of 327 non-penetrating wounds and contusions of the chest, in the English army in the Crimea, there were only 15 deaths; out of 1,509 wounds of the same kind, in the French army, according to Dr. Chenu's returns, there were 184 deaths. The Washington Circular, before quoted, refers to 4,759 flesh-wounds of the chest, and states in a general way that they presented a very small ratio of mortality.

Of the simpler wounds in which the soft parietes only are involved, little need be observed, excepting that the healing process is often a long one, owing to the natural movements of the ribs to which the wounded structures are attached interrupting the process of repair, especially when the ball has taken a prolonged course beneath the skin, and also owing to the frequent supervention of pleuritis and its consequences. The surgeon must be on his guard to watch for pleuritis arising as a consequence of these injuries, however trivial the wound or contusion produced by the projectile may at first appear. Two deaths are recorded in the *British History of the Crimean War*, under simple flesh-wounds and contusions, without fracture or pleural opening, from bullets; and in both of these the fatal termination arose from pleuro-pneumonia.

When the force with which the wall of the chest has been struck has been great, as when a heavy fragment of shell strikes at full speed against a man's breast-plate, the injury is not only liable to be followed by severe ecchymosis, but the subsequent effects of the contusion frequently show themselves in abscesses, necrosis of ribs, and sinuses of a troublesome character lasting for years afterwards. The cartilaginous, or even the bony, parietes, may be momentarily forced inwards at the time of such an injury, so that the lungs become compressed and bruised, though not opened. In such a case blood may be expectorated by the mouth in considerable quantity, and, even if no such hæmorrhage as this take place, hæmoptysis will almost invariably be one of the symptoms presented. Ecchymosis, or, at least, congestion of the lung itself to a partial extent, in all probability follows every non-penetrating gun-shot wound of the chest of much severity. Instances occasionally occur, among injuries of the chest from projectiles of large size, in which, notwithstanding no open wound of the parietes nor fracture has been caused, and no opening of the lung effected, yet death follows with all the symptoms of suffocation, apparently due to the direct result of contusion of the pulmonary structure and its consequent engorgement.

Lastly, with regard to these non-penetrating wounds, we may occasionally expect to meet with a solution of continuity in some viscus of the thorax, more especially of a lung, without any direct communication between an external opening and the wounded organ; and the injury may be accompanied, or unaccompanied, by a wound of the costal pleura. These occurrences are sometimes due to the chest-wall being forced inwards in such a way as not only to compress, but also to lacerate, a lung between the opposite walls, without fracture of bone; sometimes to a rib or ribs being broken, and the lung being wounded and penetrated by sharp points of fractured bone, in the same way as not unfrequently happens in the accidents met with in civil life. In warfare these lesions are generally the result of injuries from large projectiles of irregular form, such as fragments of shell.

Penetrating wounds.—When we examine statistically the results of penetrating wounds of the chest in warfare, we find that the mortality denoted is very large. Out of 22 officers so wounded in the Crimea, 15 died; and out of 125 men, 105 died, showing, when taken together, a mortality of 81·6 per cent. Dr. Chenu's Crimean returns show that out of 508 patients with penetrating wounds of the chest in the French army, 467 died: a mortality of 91·9 per cent. The percentages are here greatly increased by the proximity of the field-hospitals in the Crimea to the trenches in which most of the patients were wounded; had they been wounded under the ordinary circumstances of battle, they would never have reached a hospital, and would have been included in the number of dead on the field itself. The American returns are not yet complete. The records hitherto published state that 2,303 cases had been transcribed, in which either the thoracic cavity had been penetrated or the injuries had been accompanied by lesions of the thoracic viscera. The results had been ascertained in 1,272 of these cases, and were fatal in 930, or in 73 per cent. Cases of non-penetrating wounds, in which lungs had been pierced by broken ribs, and those in which the lungs had been only contused, are mingled in the American returns with the penetrating wounds: this prevents exact comparison with the results shown in the English and French Crimean returns. Fatal consequences ensue in penetrating wounds of the lungs either from primary hæmorrhage, leading to exhaustion or suffocation; from active inflammation of the pleuræ and pulmonary structure; from irritative fever accompanying profuse discharges; from fluid accumulations in one or both of the pleural sacs; from extension of inflammation to the pericardium; or from circumstances inducing secondary hæmorrhage.

In gun-shot injuries a penetrating wound of the chest is in most instances readily obvious to the sense of sight or touch. The end of the finger can be inserted, and there can be no mistake about the nature of the injury. But occasionally, notwithstanding an opening has actually been made into the chest, difficulties and mistakes in the diagnosis occur; particularly if the bullet has passed through the scapula, shoulder, or from any more distant part; if it be small, like a pistol-ball, and has entered very obliquely; or if, from accidental position of the patient, the particular part of the integument which was pierced at the time the opening was made in the chest-wall has glided away, and so left the track of the bullet covered by sound skin. Again, even when we have clear evidence that the cavity of the chest has been opened, it will be found by no means easy always to decide whether a lung has been penetrated or otherwise. The train of symptoms usually described as characterising *Wounds of the Lung* must not be expected to be all constantly present; they are each liable to be modified by a great variety of circumstances, and may each severally exist in penetrating wounds of the chest where the *lung* has escaped from being opened. It is only by a combination of symptoms, rather than by the presence of any one or other symptom, that a lung-wound can in many instances be diagnosed. Nor is it always easy to determine whether the ball has lodged or not; or, when the ball has passed through, whether fragments of bone, or other substances, have remained behind.

When the cavity of the chest has been opened by a projectile, and the lung wounded, the following circumstances may be looked for, in addition to those physical evidences of the injury which are obvious to sight and touch: a certain amount of constitutional shock; collapse, and tendency to syncope from loss of blood; hæmorrhage from the external wound; effusion of blood into the pleural cavity; hæmoptysis; and dyspnœa. If these symptoms are all present we may conclude that a lung has been wounded; but we must not conclude that a lung has not been wounded because any one or more of them are absent. Escape of air by the external wound, and emphysema, are also named by some surgeons as characteristic signs of a lung-wound. The primary symptoms will generally, but not invariably, be followed, after twenty-four hours or later, by the usual signs of inflammation in some of the structures injured. It is not possible within the limits of this article to discuss the import of these several symptoms as regards gun-shot wounds, but some of them may be briefly referred to.

The shock of a penetrating wound of the chest, apart from the collapse consequent on hæmorrhage, is not generally so marked a symptom as it is in extensive fractures of the larger bones of the extremities or in penetrating wounds of the abdomen. There is often much more 'shock' when a ball has not penetrated; when it has met something to oppose its course, as part of a soldier's accoutrements, and when, although it has not entered, it has nevertheless struck with such force as to cause a violent concussion of the whole chest and its contents.

Sudden copious *hæmorrhage* coughed into the mouth, and rapidly recurring, after a projectile has entered the chest, sufficiently indicates that a lung has been penetrated. But moderate expectoration of blood or ordinary *hæmoptysis*, although it indicates injury of some sort to the lung, by no means gives assurance that this organ has been opened. Hæmoptysis generally accompanies gun-shot wounds of the lung in a greater or less degree, no doubt always when a bronchial tube of any large size is penetrated and the lung remains pervious; but it is sometimes wholly absent, even though a lung has been extensively opened, and although the patient is troubled by cough. Dr. Fraser, in a monograph on *Wounds of the Chest*, has stated that out of nine fatal cases observed by him in the Crimea in which the lungs were wounded, only one had had hæmoptysis; and out of seven fatal cases in which the lungs were found not to be wounded, two had had hæmoptysis. This, however, from the writer's observations, would appear to be an unusual proportion of cases in which hæmoptysis was not present after lung-wounds.

Hæmorrhage *outwards* from the opening of a chest-wound does not as a general rule occur to an extent to excite the surgeon's anxiety as compared with other symptoms. Now and then, after a severe wound, when blood escapes into the pleural cavity, and the opening in the chest-wall is large and free, it will flow copiously from the external wound; and, if both the opening in the lung, as well as that in the chest-wall remains free, we shall find the blood mixed with air, and jetting out whenever the patient coughs. Or the hæmorrhage may proceed in a more direct manner from the pulmonary structure, the escape outwards being due to the effect of old close adhesions connecting the lung with the costal parietes and so making the external opening continuous with the track of the wound. More usually, however, external bleeding, when it occurs, is due to lesion of an intercostal, perhaps also of branches of the internal mammary artery, in consequence of these vessels having been torn by the sharp ends of fractured ribs.

Primary *internal* hæmorrhage is always an alarming symptom. It is the chief source of death in those cases of lung-wounds which prove mortal from the early effects of the injuries inflicted; the fatal event being sometimes induced by it rapidly after the receipt of the wound, sometimes not until two or three days have elapsed. There are no means by which the exact position of the sources of internal hæmorrhage can be determined. If immediately after a gun-shot wound, copious hæmorrhage by the mouth, and fatal syncope or suffocation quickly supervene, the inference is obvious that the projectile has opened some of the large pulmonary vessels. But when the internal hæmorrhage proceeds more slowly, it may either be derived from divided pulmonary vessels, or from some of the parietal arteries, or from both sources combined. When the blood continues to flow into the pleural sac—as indicated by the persistent blanched appearance of the patient, the cold clammy surface, increasing dyspnœa, occasional hæmoptysis, and the stethoscopic signs on ausculation—and when no traces of a source of hæmorrhage in the parietal wounds can be discovered, there can remain little doubt that it is from the structure of the lung itself that the blood is flowing. The amount of hæmorrhage in wounds of the lungs varies greatly according to the direction of the track of the ball; for the large vessels cannot here glide away from the action of the projectile, as they may in the neck or extremities of the body. The situation of the wound of entrance, or, if it be a perforating wound, the course the ball has taken, inferred from the relative positions of the wounds of entrance and exit, will therefore greatly help us to determine the probable site of the bleeding, and, to some extent its probable degree of gravity. Wounds near the root of each lung, where the pulmonary arteries and veins are largest, are attended with the greatest amount of hæmorrhage; and, as coagula can hardly form sufficiently to suppress the flow of blood, are generally fatal.

Dyspnœa is a frequent accompaniment of wounds penetrating the lung, but, again, is not an invariable symptom. When dyspnœa is greatly complained of in the early period, and is not accompanied with signs of internal hæmorrhage and pressure, it will sometimes be found to depend upon the injuries to the parietes, and to the pain caused on taking a full inspiration, or to congestion of the lung from the concussion to which it has been subjected. When a lung has been penetrated, and dyspnœa is an urgent symptom before sufficient time has elapsed for inflammatory action to have been induced, the dyspnœa may be caused by pressure upon the lung either from effusion of blood, or from accumulation of air in the pleural sac. Examination by percussion and the stethoscope will decide the existence of either of these two sources of compression. The dyspnœa, if great, indicates that the power of expansion of both lungs is interfered with by pressure; when the compression is limited to one lung, though it may be completely collapsed in consequence, especially if the opening in the chest-wall be a large one, the symptom of dyspnœa may be wholly absent. It will be readily understood how much the situation of the wound; its direction, whether communicating immediately or by a sinuous course with the pleural sac; the size of the opening; and other circumstances, must modify the occurrence of this symptom.

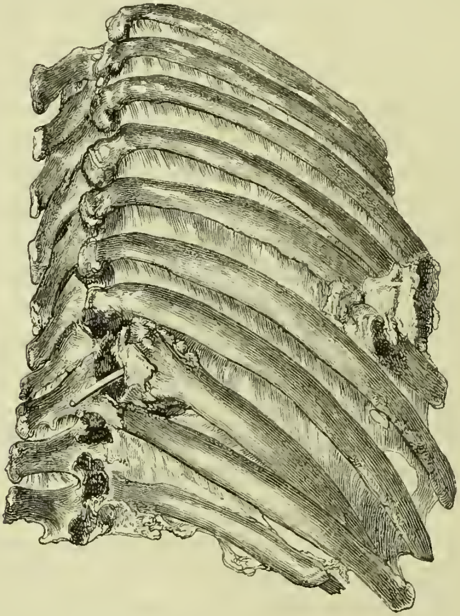
It is sometimes stated that the escape of air by a chest-wound is a sufficient proof that the lung has been opened by the projectile. Experience has shown that by itself this occurrence is not a sufficient proof of a lung-wound. Air has been noticed to escape, when it has been afterwards proved that the lung was not wounded; and no air may escape though the lung is wounded. In the former case, the air may have entered by the wound, and have been forced out again by the expansion of the lung in inspiration, or by the sinking of the chest on expiration; in the latter case, a variety of conditions, both as regards the wounded lung itself and also the chest-walls, may prevent the occurrence of this symptom. If air and frothy mucus with blood, as noticed in some cases, escape by the wound, there can be no doubt of the nature of the injury. Emphysema of a diffused kind is, again, not often seen in penetrating gun-shot wounds, though it occasionally happens. The free opening generally made by the projectile sufficiently explains this fact.

The limits of this essay prevent reference at any length to the inflammations which supervene on these wounds. Diffused inflammation of the lung itself is not so common as might perhaps be expected. In unfavourable cases, the pleural cavity is generally found to be the seat of extensive inflammatory action, with unhealthy accumulations of sero-purulent fluid, floating lymph, and broken-up clot, especially where irritation has been kept up by the presence of foreign bodies, or the patient's constitution has become debilitated from any cause.

Natural process of cure of lung-wounds.—When a case of bullet-wound of a lung progresses favourably, the following are usually the successive steps of the curative process. The pleura adjoining the seat of injury becomes inflamed, exudation occurs, and by this means the orifice of entrance in the lung, and of exit also, if the ball has perforated its structure, become adherent to the costal parietes shortly after the receipt of the injury. The openings made by the ball, both the opening in the chest-wall and that in the lung, thus become circumscribed and excluded from the general pleural cavity. In a similar way, the track of the projectile through the lung is shut off from communication with the rest of the organ by effusion into the parenchyma around it. If, however, any bronchial tubes of rather large size have been opened in the course the bullet has taken, these do not close; and, in consequence, a communication is kept up between the wound and the principal air-passages. In a few days suppuration becomes established along the track of the ball through the lung, the matter being principally discharged by the external openings of entrance and exit; the contused surface of the wound along which the ball has passed sloughs and comes away in the discharges, and the fresh surface, which thus becomes exposed, is lined with a layer of lymph. The altered texture of the parts now reduces the wound to the condition of a fistula. This, as the cure proceeds, gradually contracts, the external wounds become cicatrised, and in this way a restoration of continuity is finally established.

Sometimes when the bullet has been a very small one, another process of cure occurs. There is not formed the intimate connexion between the wound in the chest-wall and that in the lung, and there is not the escape of discharges and sloughs by the external parietal opening, but the lung-wound being diminished in size near the surface of the organ, by partial collapse of the lung-substance and from becoming plugged by coagulum, is thus excluded from communication with the pleural cavity, and the purulent discharges which follow escape through the bronchi and mouth. The wound in the chest-wall becomes healed independently of the wound in the lung.

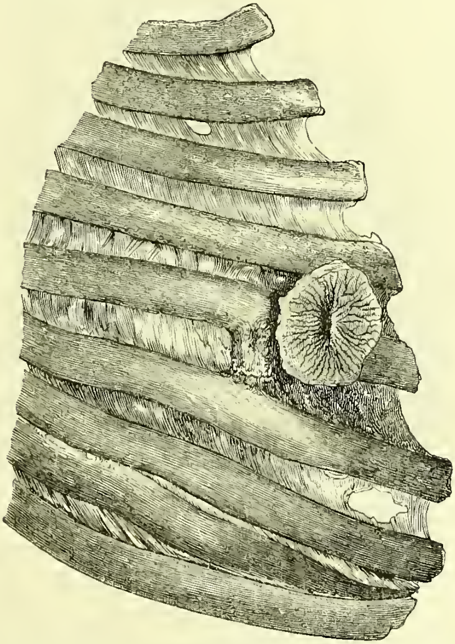
Fig. 32.



Position of the wounds of entrance and exit in the case of Pte. O. Doyle. (See text.) The probe is inserted into a sinus connected with the wound of exit. The fragments of the broken rib are firmly united, much thickened, and by their position oppose movement of the ribs above and below the seat of injury.

In some instances when the subject of a bullet-wound of the lung has lived for many years, on examination after death, the track of the ball, though completely closed, has been readily perceptible on being cut across, from part of the lung around it being consolidated to a greater or less extent; in others, in which no doubt had been felt that the lung had been traversed, the healing, presuming the diagnosis to have been correct, has been so perfect that the direction in which the ball had passed could not be detected. When the ball itself has lodged and become embedded in the substance of the lung, it is generally found sacculated in a cyst so intimately connected with the lung-tissue that they can hardly be separated from each other by dissection. When balls have thus lodged with impunity in the pulmonic tissue, they have usually been found near the periphery of the organ, and the part of the lung in which they are embedded has become adherent to the costal parietes. Thus the weight of the projectile has been partly sustained, as it were, by suspension, and pressure upon the lung substance proportionably obviated.

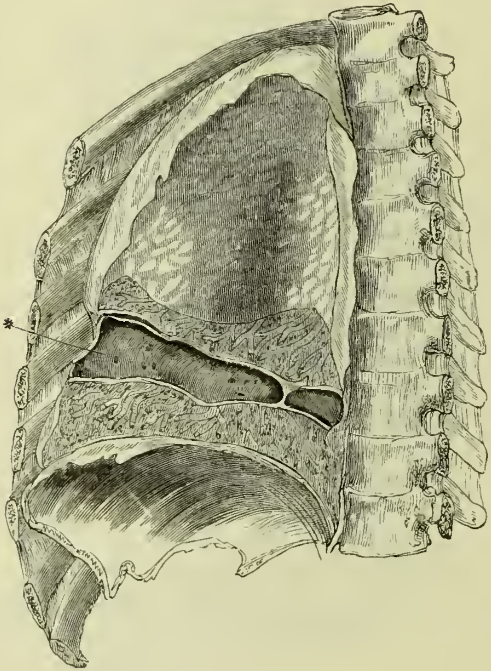
Fig. 33.



External condition of the wound of entrance in the case of Pte. O. Doyle. (See text.) The puckered and inverted portion of integument shown is firmly united to the cicatrix of the track through the chest-wall. From the *injured* rib there descends a firmly-connected and strong piece of bone, originally a splinter torn and pushed aside by the bullet, and this meets an exostotic growth from the *uninjured* rib below, so as together to form a column of support to the damaged structures above.

The first of the two healing processes of a gun-shot wound of the lung described is well illustrated by Figs. 32 to 34. They are taken from a preparation in the Army Medical Museum at Netley. The history of the case is briefly as follows. The patient, Private O. Doyle, a young soldier, was subjected to a perforating wound of the right side of the chest and lung by a musket-ball on November 26, 1857, in India. He returned to England in August 1858, and on the 15th of October of the same year, eleven months after his wound, died of gangrene of the left, or unwounded, lung. The wound of entrance, which was between the sixth and seventh ribs, four inches to the outer side of the right nipple, was then soundly healed; the wound of exit, which was between the tenth and eleventh ribs, close to the spine, had been prevented from becoming completely closed by the lodgment towards the termination of the track of the ball of some small pieces of bone which had been torn away from the ribs in front by the bullet in its passage. The steps taken by nature to aid the curative process by arresting as far

Fig. 34.



Internal view of the track of the ball in the case of Pte. O. Doyle. (See text.) The firm union of the opening of entrance in the lung to the opposite portion of the chest-wall, the track of the ball through the lung lined with false membrane, and the open ends in it of small bronchial tubes, are points worthy of note.

as possible the movements of the ribs at the respective seats of injury are worthy of observation.

Treatment.—The object of the surgeon's care must be, in the first place, to arrest hæmorrhage; secondly, to remove pieces, or jagged projections, of bone, or any other sources of local irritation; and, thirdly, to adopt measures for the prevention of all interference with the natural process of cure previously described. Although the shock may happen to be considerable, attempts to rally the patient, if any be made, should be conducted very cautiously; the prolongation of the depressed condition may be valuable in enabling the injured structures to assume the necessary state for preventing hæmorrhage. Hæmorrhage from vessels belonging to the costal parieties should be arrested by ligature, as in other parts, if the source from which it proceeds can be ascertained, and if the flow of blood be so free as not to be controlled by pressure and ordinary styptics. If attempts at applying the ligature fail (and it is a difficult operation in the case of an intercostal artery—so much so, that a variety of instruments have been devised for the purpose of accomplishing this special object, though all of doubtful utility), the best plan is to plug the opening. This may be done without any risk of pushing foreign bodies into the cavity of the pleura in the following way. A large piece of linen is laid upon that part of the chest in which the wound is placed, and the middle portion of this linen is pressed into the wound by the finger, so as to form a kind of pouch. This pouch is then distended by sponge or lint pushed into it until the pressure arrests the bleeding; on stretching out the corners of the linen cloth the pressure of the plug will be increased. The whole may finally be secured to the chest by a bandage or roller. Hæmorrhage from the lung itself must be treated on the general principles adopted in all such cases; the administration of cool acid drinks, iced, if ice can be obtained, perfect quiet, and the administration of opium or digitalis. When blood has accumulated in any large quantity, and the patient is so much oppressed as to threaten suffocation, all coverings must be removed, and the blood be permitted to escape by the wound; the wound should even be enlarged, if necessary, so as, with the assistance of proper position, to facilitate its escape. If the effused blood, from the situation of the wound, cannot be thus evacuated, and the patient be in danger of suffocation, then paracentesis must be resorted to.

The extensive early bleedings formerly recommended in penetrating gun-shot wounds of the chest for the purpose of arresting internal hæmorrhage are now rarely practised by English surgeons. Should the patient survive, the extreme drain thus effected appears to interrupt afterwards the process of adhesion between the pleural surfaces, and to arrest the steps which might otherwise be taken by nature to repair the existing mischief, while it leads the injured structures into a condition favourable for gangrene, or encourages the formation of ill-conditioned purulent effusions in large amount.

If the wound be not attended with active hæmorrhage within the cavity of the chest, if any bleeding there may have been from the external wound has been stopped, as soon as all splinters or other local sources of irritation have been cautiously removed, a pledget of lint should be laid over the opening, and a broad bandage placed round the chest, just tight enough to support the ribs, and in some degree to restrain their movements. An opening should be made in the bandage over the site of the wound large enough to permit the ready access of the surgeon to it, if necessary, and to allow the escape of discharges. When there is only one wound, the patient should be laid on the wounded side, if his comfort admits of it, and with the wound downwards. This is done with a view to prevent accumulation of fluid in the pleura; and, at the same time, to allow freer action of the chest on the uninjured side for respiration. If there be two openings, as will most frequently be the case in rifle-ball wounds, one wound should be placed downwards in the manner just mentioned, and the wound which will then be uppermost should be kept covered. The most perfect quiet that can be obtained should be enjoined, and opium may be freely given for aiding this object.

When these arrangements have been carried out, the surgeon will next have to turn his attention to meeting the dangers of inflammatory action, especially in the pleura, lungs, and pericardium. The general treatment of pleurisy or pneumonia after a gun-shot wound will not differ materially from the treatment of the same inflammations when arising from other causes. The chief difference in condition is that in almost all cases of penetrating wounds air will have been admitted into the pleura, and empyema, or sero-purulent effusions mixed with broken-up clot, will occur as a consequence. Here again of late years the practice of bleeding which was formerly enjoined in all such cases by military surgeons, not only as the best means of obviating internal hæmorrhage (which has been already referred to), but also as the best remedy to be relied on afterwards for preventing and reducing inflammation, is now seldom resorted to. The use of calomel to salivation is also almost entirely abandoned. Everything calculated to lower the general strength is rather avoided. More reliance is placed on careful nursing, regimen, and dieting, and in restraining vascular excitement within due bounds, by the exhibition of medicines whose influence on the constitution is not of so permanent a character as is that of mercury. If the inflammatory action be excessive, small doses of tartarised antimony, digitalis, and the usual purgatives, are employed to combat it; but, even with these, the patient's strength is supported by appropriate means, especially in cases where suppuration is profuse. Venesection has been proved by modern experience not to prevent inflammation taking place, and has seemed to give it, when it has arisen, more power over the weakened structures. In the Crimean campaign, in which the circumstances of the period led for the first time army surgeons to depart from the doctrines so strongly enforced by Guthrie, Hennen, and other eminent military practitioners of the Peninsular period, not a few instances of favourable recovery took place after lung wounds without venesection being resorted to as any part of the treatment. The case of an officer of the 19th Regiment, who was shot at the assault of the Great Redan, and under the care of the writer, will serve to illustrate some of the points before named. In this instance, a rifle-ball passed through the upper part of the left scapula near its superior posterior angle, comminuting the bone and entering the chest. The ball, together with a piece of cloth, was excised in front, two inches above and internal to the fold of the axilla. The mouth was filled with blood immediately after the injury; bloody expectoration continued for three days; there was hacking cough on increased inspiration; the respiratory murmur was accompanied with slight crepitating *râles* in the upper part of the lung; there was weakness, but not much 'shock.' This officer, like almost all others who were then with the front of the army before Sebastopol, had been much weakened in frame by scorbutic diarrhœa in the winter of 1854–55, so that it appeared very objectionable to lower his vital force by any means; and though the cure was protracted by occasional attacks of diarrhœa subsequently to the injury, by profuse discharge from the wounds, and separation from time to time of spiculæ of bone, he left for England two months afterwards with his recovery nearly completed, and no inconvenience from the wound has been experienced in the discharge of his duties since. No venesection at all was practised in this case; but tonics, nourishing diet, and port-wine were given as soon as suppurative action had been established. The reports which have reached us from the United States tend to show that bleeding was scarcely ever practised during the late war in that country for chest-wounds; indeed, in the Circular from the Surgeon-General's office before quoted, it is stated that, 'in the treatment of penetrating wounds of the chest, venesection appears to have been abandoned altogether.'

While thus dwelling, however, on the successful treatment of chest-wounds without venesection, it is only right to mention that the opinion of some thoughtful surgeons in the Crimea did not coincide in the views of those who regarded bleeding as not only useless but injurious. Some indeed considered that more lives would have been saved had the lancet been used more freely.* In some instances in the Crimea the successful issues appeared to have been owing to copious venesection. A remarkable case in point occurred in a young soldier of the 33rd Regiment, private Thomas Monaghan, under the care of Dr. Muir, who has since attained so eminent a position in the army medical service. The patient was wounded in August 1855, through the left shoulder-joint and chest, the glenoid cavity and head of the humerus being injured, and the lung implicated. In this instance complete recovery as to the chest, and recovery with partial anchylosis of the shoulder, without operative interference, followed, and appeared attributable chiefly to inflammatory action being kept under by repeated venesection, the use of antimonial medicines, and enforced abstinence. In two other cases, which occurred during the same month under Dr. Muir's care, successful terminations appeared to be attributable to the use of similar means. In one of these the ball entered the front of the chest, between the third and fourth ribs, and passed out between the seventh and eighth ribs below; in the other, after passing through the right arm, it entered the chest at the posterior border of the axilla, and emerged near the apex of the scapula. More extended statistical information, with careful analysis of individual cases, is required before the question of the proper treatment of chest-wounds, so far as venesection is concerned, can be regarded as a settled one. Perhaps when the whole of the vast experience recently gained in the War of the Rebellion in the United States has been well collated and is made public, the question will be in a great measure solved.

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* See the remarks on this subject in Dr. Macleod's *Notes on the Surgery of the War in the Crimea,* p. 237. London, 1858.

A plan of treating gun-shot wounds of the chest by hermetically sealing their external orifices, was introduced during the late war in America by Dr. Howard, of the United States' army. A description of the process, with the presumed objections to it in practice, may be found in a published lecture on the subject by the writer of this essay, in the *Lancet* of January 2, 1864. The Washington report before quoted has since commented on the plan as follows :—' The record of the results of the so-called method of "hermetically sealing" gun-shot penetrating wounds of the chest are sufficiently ample to warrant an unqualified condemnation of the practice. The histories of the cases in which this plan was adopted have been traced, in most instances, to their rapidly fatal conclusion.' *

GUN-SHOT WOUNDS OF THE ABDOMEN.

Gun-shot wounds of the abdomen, like those of the chest, naturally divide themselves into *non-penetrating* and *penetrating*. The *non-penetrating* may be either simple flesh-wounds or contusions, or may be accompanied with fracture of some of the pelvic bones, or with injury to some of the contained viscera. In *penetrating* wounds, the peritoneum only, or together with it, one or more of the abdominal viscera, may be wounded; or, in comparatively rare cases, a projectile will so enter that a viscus is penetrated without the peritoneum being involved. It is in the regional cavity of the abdomen that the proportion of penetrating wounds is the greatest. The cranium, from its toughness, form, structure, and coverings, serves as a strong defence against penetration of the brain even by gun-shot; the osseous yet elastic and movable ribs, the scapulæ, sternum, and the muscular parietes, with their convex outline, greatly protect the contents of the cavity which they enclose; but the extensively exposed surfaces of the abdomen, anteriorly and laterally, have scarcely any power of resistance to offer against a projectile impinging upon them; and when this important cavity is once opened by these means, whether the projectile lodges within it or otherwise, death is the usual result. Even the chances of a favourable termination which may exist in wounds from other causes are generally wanting in gun-shot wounds; and much of the treatment, such as the use of sutures, and of other means that can be adopted to insure the apposition of cut edges, is inapplicable here, from the parts to a certain distance being almost necessarily deprived of their vitality in injuries from gun-shot.

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* *Circular* No. 6, p. 22, Washington, Nov. 1865. A reply by Dr. Howard to the remarks in the lecture published in the *Lancet* of Jan. 1864, appeared in the *Amer. Journal of Med. Sciences* of October, 1864.

Non-penetrating wounds are not proportionally so grave as their nearness to the peritoneum and the important organs invested by it might lead us to anticipate. Out of 115 non-penetrating wounds and contusions by projectiles of all kinds, in the English army during the Crimean campaign, 22 deaths occurred, or 19·1 per cent.; out of 328 similar cases in the French army, there were 54 deaths, or 16·4 per cent. The proportion of recoveries in the American returns appears at first sight to be much larger. They show only 114 deaths out of 2,164 flesh-wounds and contusions of the abdomen, or 5·2 per cent.; but all cases in which the abdominal viscera were injured are excluded from these numbers, which probably explains the great difference between the comparative mortality shown in them and in the Crimean returns.

The fatal injuries which occasionally occur from masses of shell, or round shot, in which the liver, spleen, or other viscera are ruptured without penetration of the abdominal parietes, and where death ensues from shock, hæmorrhage, or peritonitis, have been alluded to in the general remarks. If the parietes have been much contused, abscess or sloughing may be expected; and a tendency to visceral protrusion must be afterwards guarded against, in case of recovery. The 'Washington Circular,' before quoted, mentions that the 114 deaths among the non-penetrating wounds resulted in most instances from sloughing after injury to the abdominal walls by shells.

Non-penetrating wounds complicated with fractures of pelvic bones are not included in the foregoing numbers. When these bones are fractured by heavy projectiles, and the injuries do not prove directly mortal, very protracted abscesses generally arise, connected with necrosed bone; and the vital powers of the patient are greatly tried by the necessary restraint and long confinement. The great force by which these wounds must be produced, and the general contusion of the surrounding structures, cause a large proportion sooner or later to end fatally, notwithstanding the peritoneal cavity has escaped from being wounded. Of 29 such cases which came under treatment in the English army in the Crimea, 16 died, or 55 per cent.; of 111 cases in the French army, 81, or 72·9 per cent. Of 185 cases in the United States' armies of which the results are published, 77 died, or 44·2 per cent.

Penetrating wounds.—The ratio of recoveries after these wounds in both the French and English armies in the Crimea was very small. Out of 124 penetrating wounds of the abdomen in the English army, 115, or 92·7 per cent., died; out of 121 in the French army, 111, or 91·7 per cent., died. The 'Washington Circular,' before quoted, states that of 543 cases in which 'the peritoneal cavity was penetrated, or the abdominal viscera injured,' the results had been ascertained in 414, and were fatal in 308, or 74 per cent.

A penetrating wound of the abdomen, whether viscera be wounded or not, is usually attended with a great amount of 'shock.' When, in addition to the cavity being opened, viscera are penetrated, and death does not directly ensue from rupture of some of the larger arteries, the shock is not only very severe, but the collapse attending it is seldom recovered from, up to the time of the fatal termination of the case. This is sometimes the only symptom which will enable the surgeon to diagnose that viscera are perforated. The mind remains clear; but the prostration, oppressive anxiety, and restlessness are intense; and as peritonitis supervenes pain, short and hurried respiration, diffused tenderness, irritability of the stomach, distension, and the other signs of this inflammation, are superadded.

In the greater number of wounds from musket-shot, scarcely any matter will escape from the opening in the parietes, the margin of which becomes quickly tumefied; but if any escape, it will probably indicate what viscus has been wounded. If the stomach has been penetrated, there will probably be vomiting of blood immediately after the wound, and great pain and distress about the seat of injury, especially when the straining in vomiting occurs. If the liver be wounded, death usually results from primary hæmorrhage, or from inflammation consequent upon extravasation into the peritoneum. In a few instances patients have recovered after gun-shot wounds involving this viscus. About twelve instances altogether have been published by Guthrie, Hennen, Cooper, and others who were engaged in military practice during the Peninsular campaigns. Only one case is known to have survived from the Crimean war; and, having had the opportunity of ascertaining the effects of the wound for several years after the date of the infliction, the writer has recorded the case in full in the 4th vol. of Army Medical Reports.* Two officers who were shot through the liver by musket-balls, during the Sepoy mutiny in India, recovered. The cases are described in the *Indian Annals of Medical Science* for January 1859. Four instances of recovery during the late war in the United States are referred to in the Surgeon-General's report of 1865.

When the small intestines have been perforated, it occasionally happens that feculent matter escapes by the wound; in the majority of cases, however, no such evidence is afforded. If death follows soon after from peritonitis, the bowels usually remain unmoved, so that no indication is offered of the nature of the wound from evacuations; but in any case of penetrating wound of the abdomen, when the opportunity is offered, steps should be taken—a matter not unlikely to be omitted under the circumstances of camp-hospitals full of patients—to isolate and examine all evacuations which may follow. By attending to this direction, the writer had the satisfaction of ascertaining the subsequent passage of a ball and piece of cloth, in a case where the bullet had entered the loin near the spinal column and lodged.

Recoveries after penetrating wounds of the small intestines by gun-shot are very rare. In the Army Medical Museum at Netley there is a preparation of jejunum, which was supposed to have been perforated in three places by a musket-ball. It was taken from a private of the 80th Regiment, who was shot through the abdomen at Ferozeshah, in 1845, and who died from cholera in 1851. Inspector-General Taylor, C.B., then surgeon of the regiment, who made the examination post-mortem, thus described the injured part of the intestine: 'The intestines, neither there nor elsewhere, were morbidly adherent, but the fold of intestines immediately opposed to the cicatrix presented a line of contraction, as if a ligature had been tied round the gut. The same appearance existed in two other places.' It seems more likely that the gut was contused than perforated, and that the three constrictions which are still seen in the preparation, gradually supervened on the injury; more especially as no adhesions were found, and as when the wound was inflicted, the symptoms were so slight as to have led to the supposition that the ball had gone round the abdominal wall.

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* History of a case of gun-shot wound of the liver, with remarks, *Army Med. Dept. Reports*, p. 502. London, 1864.

Gun-shot wounds of the large intestines, especially the ascending and descending portions of the colon, are less fatal than wounds of the small intestines; probably from structural causes, as well as circumstances depending on position, from the gut being so tied down that escape and diffusion of fæcal contents into the peritoneal cavity is less likely to occur, and from its being only partially invested by peritoneum.

An occasional result of a gun-shot wound of the intestines, more especially of the colon, is fæcal fistula, and, by means of this way of escape for fæcal and other discharges, life is sometimes saved. One such case only occurred in the Crimea, and this happened in the 19th Regiment, of which the writer was then the surgeon. This case subsequently passed under the care of his friend Mr. Birkett, of Guy's Hospital, in which institution the patient died from the effects of albuminuria, four years after the receipt of the wound referred to. The surgical history of this case has been already published in the *Lancet*;* the medical history, together with the results of the post-mortem inspection, have been detailed by Dr. Habershon, in vol. v., ser. iii., of the *Guy's Hospital Reports*. The fistula became closed at intervals, and occasionally, before other disease supervened, hopes were entertained that complete recovery might result. The direction and depth of the wound precluded any of the usual operations for attempting to effect a radical cure. Two cases of abnormal anus by gun-shot perforation were recorded by Dr. Williamson, among the wounded who returned from India after the Sepoy mutiny; in both instances the descending colon was the part of the bowel implicated. The Washington report states that fæcal fistulæ were produced in many survivors after gun-shot wounds of the abdomen, and gives the particulars of eight such cases. It further states that the fistulæ 'commonly closed after a time without operative interference, reopening at intervals and then healing permanently.'*

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* For 1855, vol. i. p. 606, and vol. ii. p. 437.

If the kidneys or bladder are so wounded that there is a direct communication between the wound and the sac of the peritoneum, a fatal result is almost inevitable from inflammation; but if they are wounded in such a way as not to include their peritoneal investments, they have not the same fatal character. When the bladder is opened by a projectile which does not perforate the viscus, the lodgment of the latter within it is almost a necessary consequence. Mr. Dixon, of St. Thomas's Hospital, published in the 33rd vol. of the *Medico-Chirurgical Society's Transactions* a list of all the cases in which the operation of lithotomy was known to have been performed for the extraction of bullets, or of calculi of which bullets formed the nuclei, up to the date at which he wrote. They were 15 in number. The lodgment of a bullet was ascertained to have happened in a soldier of the 20th Regiment, in the Crimea; but the patient died from other injuries, so that the information could not be turned to account. A case which occurred during the late war in the United States is noted in the Washington report, in which a fragment of a grenade, weighing upwards of 2 oz., was extracted by lithotomy; the fragment had reached the bladder through the right natis. Small foreign bodies may also pass into the bladder by way of the ureter. Mr. Guthrie mentions some wounds of the kidney where recovery took place; in one, seven months after the wound, after an attack of retention of urine, a piece of cloth was forced out by the urethra, which must have come down from the pelvis of the kidney.

Instances are recorded in which balls have passed directly through the abdomen without perforating any important viscus. As an example, on the other hand, of the number of wounds which may thus be inflicted, a soldier of the 19th Regiment, on duty in the trenches before Sebastopol, who was shot through the abdomen in the act of defæcation, was found by the writer, on post-mortem examination, to have had as many as sixteen openings made in the small intestine. He survived the wound nineteen hours.

Wounds of the diaphragm.—Musket-balls occasionally pass through the diaphragm, and Mr. Guthrie has remarked that these wounds, in instances where the patients survive, only become closed under rare and particular circumstances. Hence the danger of portions of some of the viscera of the abdomen, as the stomach or colon, passing into the chest, and thus forming diaphragmatic herniæ: and of these eventually from some cause becoming strangulated. Two very interesting preparations of these accidents from gun-shot exist in the Museum at Netley. In both instances, the stomach, colon, and omentum form the hernial protrusions. In one, death occurred a year after the wound, from strangulation induced suddenly after a full meal; in the other, the soldier continued at duty twenty-two years after the wound, and then died from other causes. All the cases which occurred in the Crimea, in which openings had thus been established between the cavities of the chest and abdomen, proved fatal. One case occurred where the patient survived a double perforation of the diaphragm, together with a wound of the liver, six days; in another instance, where the lung, diaphragm, liver, and spleen were wounded, the soldier lived sixteen hours. The apparent direction of the ball, hiccough, dyspnœa accompanied with spasmodic inspiration, and inflammatory signs more particularly connected with the chest, will be the usual indications of such a wound. In case of recovery, the risk of hernial protrusion and strangulation should be explained to the patient. Should strangulation occur, it can hardly be expected that division of the stricture could be performed, without the operation itself leading to nearly as certain fatal results as the condition it would be employed to remove.

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* *Circular* No. 6, p. 25.

Treatment.—In the treatment of most penetrating wounds of the abdomen by gun-shot, the surgeon can do little more than soothe and relieve the patient by the administration of opiates; and, if the patient survives long enough, to treat symptoms of inflammation when they arise on the same principles as in all other cases. The removal of a soldier wounded in the abdomen from the place where he has fallen should always be conducted in the most easy and cautious manner; and before the transport is commenced a full dose of opium or morphia should be administered to him. The advisability of an early administration of a dose of morphia may be taken as a general rule for all such cases. The use of this remedy is most important, not merely to allay pain and nervous excitement, but also to stop the peristaltic action of the intestines as much as possible. By its aid, if an opening has been made in a part of the intestine, perhaps escape through it of the bowel contents into the peritoneal cavity may be prevented; and if the opiate treatment be continued at intervals, and perfect rest enjoined after the man has arrived at hospital, perhaps such a state of quiet may be produced at the seat of injury, that the wounded parts may become isolated, and agglutinated to neighbouring structures by effused lymph, so as to stop further communication with the general cavity of the abdomen. No brandy or other stimulant should be given: the collapse which attends such injuries may be useful in checking hæmorrhage; and the exhibition of stimulants is further contra-indicated by the risk of exciting too much reaction, should the wound not prove directly fatal. The diet and drinks should be most limited in quantity; indeed, for the first two or three days nothing but a little water should be allowed. In short, all the early treatment should be directed to insuring rest as complete as possible, not merely of the patient generally, but also local rest—most especially of the abdominal viscera which may have been involved in the injury—and, at the same time, to limiting inflammatory action in the wounded serous sac to the narrowest bounds.

If the wound be one in which intestine protrudes, and the latter be found to be entire, it must be dealt with on the same principles as protrusions after incised or ordinary torn wounds; but if the protruding intestine is found to have been opened by the projectile, or if from the length of time which has elapsed before the constricted bowel has been brought to the notice of a surgeon it has become gangrenous, not simply congested, the part so wounded or so gangrenous should not be returned. Steps in such a case must be taken to try and form an artificial anus, and so to imitate the usual means of natural cure when recovery follows a gun-shot wound with penetration of intestine. It must be remembered that sutures are not to be applied to the edges of a gun-shot wound without previously paring them and removing the parts which have been contused by the action of the projectile.

When the bladder is penetrated, care must be taken to provide for the removal of the urine, either by an elastic catheter, or, if this cannot be retained, by perineal incision. A freely communicating external wound prevents the employment of the catheter from being essential. A soldier of the 57th Regiment was wounded on the 18th June 1855 by a musket-ball, which entered the left buttock, fractured the pelvis, and came out about three inches above the os pubis, and one inch to the right of the median line. The bladder was perforated; urine escaped by both openings, chiefly by the one in front. Here the catheter caused so much irritation that it was withdrawn; but the posterior wound soon ceased to discharge urine, and in eighteen days the anterior wound was free from discharge also. Seven weeks after the date of injury, symptoms resembling those of stone in the bladder came on; these were relieved on three spiculæ of bone making their escape by the urethra. About the same time the anterior wound became again open, and some pieces of bone were discharged. After 97 days' treatment in the Crimea the man was sent home; the anterior wound being still so far open that distension of the bladder, as from accumulation at night-time, led to a little oozing from it. This subsequently healed, and he was sent to duty on the 22nd of November, nearly six months after the date of injury.

GUN-SHOT WOUNDS OF THE PERINEUM AND GENITO-URINARY ORGANS.

From the position of these parts of the body, uncomplicated gun-shot wounds of them are comparatively rare. Fifty-six cases, however, occurred among the soldiers of the English army in the Crimea, from the 1st April 1855 to the end of the war, and among these were 17 deaths, or 30·3 per cent.; while out of 234 in the French army, there were 77 deaths, or 32·9 per cent. Out of 457 cases of genito-urinary wounds noted in the 'Washington Circular,' before quoted, there were 37 deaths, or only 8 per cent. The deaths among the men in the English army chiefly resulted from extensive laceration involving the urinary apparatus. Three men only, out of 935 who have been invalided on account of wounds received in the Indian mutiny, were sent home for wounds of this class. In one of these, the injury was from a spent shot, which caused a bruise without laceration over the symphysis pubis, and produced persistent incontinence of urine; in each of the other two, a musket-ball wounded the left testicle, injured the urethra, and led to urinary fistula. The fistulæ were, however, subsequently cured.

In one patient, the testicle was so much injured that it was removed on the day the wound was received; in the other, it sloughed away shortly after.

Perineal wounds are not unfrequently caused by shells bursting and projecting fragments upwards; but they are generally mixed with lesions of viscera of the pelvis, or fracture of its structure, or extensive laceration often involving the upper parts of the thighs or buttocks. Separate wounds of the external organs of generation are usually caused by bullets, which often pursue very curious tracks through their structure. In two cases in the Crimea, a bullet entered between the glans penis and prepuce, and traversed upwards without penetrating the erectile tissue. M. Appia records a case where the ball entered the summit of the glans, traversed the whole length of the corpus cavernosum, passed under the pubic arch, and went out by the right buttock. The urethra was not opened. In another case, a ball carried away the inferior part of the glans, but did not wound the urethra. A soldier of the Rifle Brigade was wounded in the Crimea by a musket-ball, which entered the right buttock and came out by the body of the penis, just below the glans. In this case the urethra was ruptured about four inches from the meatus. The wound of the penis closed favourably. When one lateral portion of the corpus cavernosum is perforated by a bullet, the loss of substance, and the contraction caused by the process of cicatrisation, lead to such distortion when the organ is distended, as not only to cause pain but also to render sexual intercourse impracticable. Operative interference becomes necessary to remedy this condition. The fact of bullets occasionally lodging in the scrotum should be remembered in cases of wounds about the perineum and genito-urinary organs, when the site of lodgment of a projectile cannot be readily discovered.

Gun-shot Wounds of the Extremities.

These injuries, always very numerous in warfare, offer many subjects of consideration for the military surgeon. No class of wounds includes so many cases that remain under his care for long periods as this class. As already shown, a large proportion of wounds of the head and trunk are immediately fatal, or from the commencement contain the elements of fatal results, while wounds of the extremities, if those of the thigh be excepted, are free from this extremely serious character. The treatment to be pursued, including questions of conservation, resection, amputation, and the proper time for the adoption of these latter, if determined upon, often demands the closest attention of the surgeon. These subjects will be considered in their general bearing in other parts of this work, and only points especially connected with the circumstances of warfare will be here referred to.

Gun-shot wounds of the extremities divide themselves into flesh-wounds and contusions, and those complicated with fracture of one or more bones. Flesh-wounds may be simple, and these offer few peculiarities, whatever their site; or they may be accompanied with lesion to important nerves, or blood-vessels, or both, and these complications generally entail serious consequences. The latter usually increase in gravity in proportion as the injuries approach nearer to the trunk.

When a gun-shot wound of an extremity is complicated with fracture, the lesion is usually rendered compound by the direct contact of the projectile with the injured bone. Occasionally the fracture is simple; when this happens, it is generally caused by indirect projectiles, such as stones or splinters, or by spent balls.

The following complications, in addition to those already mentioned, not unfrequently accompany injuries of this class, as they are met with in military practice: extensive laceration of soft parts; lodgment of the projectile, either entire or in fragments; injuries to distant organs from the projectile continuing its course into the trunk; and lastly, extension of fissures from the seat of fracture into an articular extremity, and consequent opening of a joint. The serious aggravation of injury which constantly occurs from the mischievous effects of transportation from the place where a soldier has fallen to the field-hospital, and again subsequently from the field to the general hospitals in rear, must also be taken into account when estimating the conditions and results of gun-shot fractures of the extremities under the circumstances of warfare. The critical influence which is exerted upon a shattered bone with an open wound, or upon an articulation penetrated by gun-shot, by the distance the patient has to be carried, and by the kind of means employed for effecting the transportation,* and the paramount importance in military practice of preventing local movement of the parts involved in such injuries, by plaster of Paris or other closely adapted and immovable supports, can hardly be said to have yet attracted sufficient general attention in England.

Simple flesh-wounds have already been referred to both in respect to their nature and treatment in the commencement of this essay. It is in connection with fractures of bones and their proper treatment that the interest of surgeons is chiefly attracted in gun-shot wounds of the extremities. From the nature of the injuries, already described, to which bones are subjected by the modern weapons of war, together with the irreparable nature of the wound in the softer structures, except after a long process of suppuration and granulation, as well as from the usual circumstances of military practice, it might be anticipated that difficulty would often arise in determining which of the double set of risks and evils—those attending amputation, and those connected with attempts to preserve the limb with a profitable result—would be least likely to prove disadvantageous to the patient. Experience in such injuries has established certain rules which are now generally acted upon; some still remain *sub judice.*

Some of the varieties of fractures which result from gun-shot in the long bones of the extremities can scarcely be produced by any other agents besides projectiles. This fact is chiefly observed among partial fractures, which are rare accidents in civil practice, while in military practice they are by no means uncommon. Thus military surgeons meet with the following instances of partial fracture: 1. Removal of portion of a bone by the projectile making a furrow in its passage across its surface—grooving it: 2. Removal, splintering off, of longitudinal fragments from the external cylindrical part of a bone; 3. Removal of part of the bone by completely punching out a portion, thus leaving a hole through the entire substance of the bone; and 4. Partial fracture by driving inwards part of the external cylinder, and causing the fragment to lodge in the cancellated structure. This latter partial fracture is generally attended with lodgment of the projectile also. Among the complete fractures, those attended with general comminution, in the neighbourhood of the part of the bone struck, with dispersion of the fragments among the surrounding soft tissues, and those which may be spoken of as 'resecting fractures,' can hardly be caused accidentally, except by firearm projectiles. The latter fractures result when a rifle-ball at high speed strikes one of the smaller long bones of the extremities, as the fibula, one of the bones of the forearm, one

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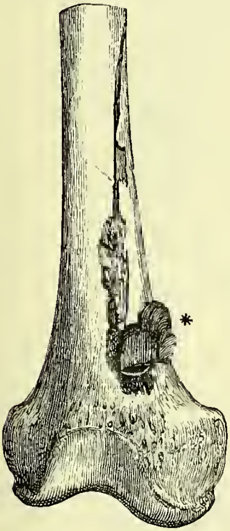
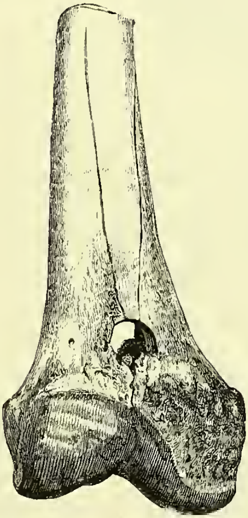
* See, on this subject, *A Treatise on the Transport of Sick and Wounded Troops*, pp. 514, London, 1869, by T. Longmore, printed under the superintendence of H.M.'s Stationery Office, and sold by Longman & Co., &c.

FIG. 35.



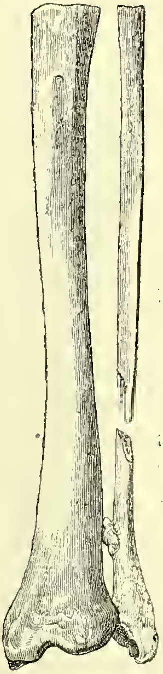
Partial gun-shot fracture. Lateral splintering. (See remarks in the text.) * The bullet lodged; the lead being cut into, and a thin segment turned back by the sharp edge of the fractured bone.[*]

FIG. 36.



Partial gun-shot fracture. Perforation with fissuring. (See remarks in the text.)[†]

FIG. 37.



Resecting gun-shot fracture of the fibula. The natural stay, or buttress of bone below the seat of injury, which has been thrown out to support the lower fragment, is worthy of note.[‡]

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[*] Spec. No. 132 in the Army Medical Museum at Washington.

[†] Spec. No. 76 in ditto.

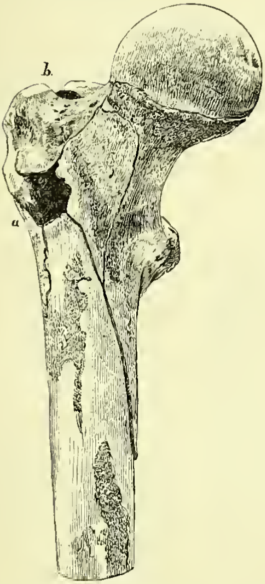
[‡] Spec. No. 3692 in the Army Medical Museum at Netley.

or two of the metacarpal or metatarsal bones, without coming into collision with the adjoining bone or bones of the same portion of the extremity. In such a case, a portion of the bone struck, including its entire circumference, is liable to be cut out of it, to be 'resected,' leaving the broken surface of the remaining upper portion of the shaft separated by a certain interval from the broken surface of the lower portion. This is a noticeable fracture, for the impossibility of bringing the two broken surfaces into contact with each other has a material influence, when a certain limit of separation is passed, in preventing any process by which they can become united. The drawings (Figs. 35, 36, 37) will serve to illustrate some of the kinds of special fracture above mentioned.

When conoidal bullets happen to strike on or below the trochanters of the femur, they usually leave the head and neck of the bone intact, but cause fissures which often extend to a long distance down the shaft; when they pierce the head, all the parts below usually escape fracture; when the neck is perforated, the fracture generally extends both upwards and downwards. The same rule holds good with regard to the upper articulating extremity and tubercles of the humerus, but not in so marked a manner, owing to the modified form and development of the corresponding parts in this bone. When, therefore, in a wound about the hip or shoulder-joint, an observation by the finger of the particular spot which has been struck is practicable, a recollection of the circumstances just mentioned facilitates the diagnosis of the probable extent of the injury effected, and furnishes a point for consideration when settling the treatment to be adopted. The drawings (Figs. 38 and 39) serve to illustrate fractures produced by conoidal balls which have penetrated the greater trochanter and head of a femur.

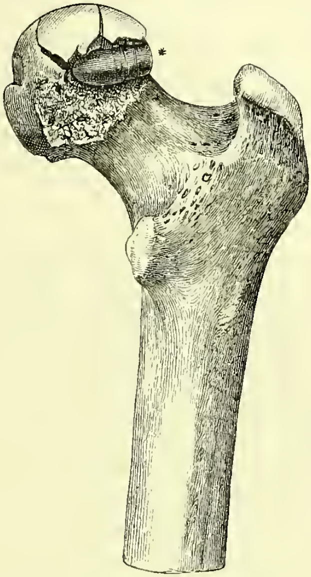
Although the subject of pyæmia is considered in its general bearings elsewhere, it is right to mention here that this serious complication, as met with in gun-shot wounds, appears to be especially induced by injuries of bones, particularly those of long bones in which the medullary canal has been laid open and extensively splintered. Several circumstances probably conduce to this result: its chief local causes are the prolonged suppurative action during the removal of sequestra, the irritation caused by sharp points and edges, sometimes increased by transport from primary to secondary hospitals, the patulous condition of veins in bones leading to thrombosis; while depressed vital power from any cause, and continued exposure to an impure atmosphere from the congregation of numerous patients with suppurating wounds, are the principal agents in producing the state of constitution favourable to its development and progress. Unless the hospital miasmata engendered in this way are constantly removed as they arise, or, at least, very greatly diluted, by proper ventilation, it is almost impossible that patients labouring under severe wounds of the extremities with comminuted bony fractures can be long saved from septicæmia and pyæmia; and these, when they supervene, rarely lead to any but a fatal termination. The different conditions of hospital air, which in one set of cases lead to the appearance of hospital gangrene, in another set of pyæmia, have not been properly defined; but

FIG. 38.



Upper portion of right femur, showing the injury produced by a conoidal bullet. The projectile has entered at the trochanter major and made its exit upwards through the posterior part of the neck of the bone.*

FIG. 39.



Upper portion of right femur, showing the injury produced by a conoidal bullet which has penetrated the head of the bone.†

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* Spec. 710 in the Army Medical Museum at Washington.

† Spec. 125 in ditto.

from the frequency with which the latter complication follows wounds of bones, it would seem that an especial influence is exerted by the local peculiarities, already mentioned, of these injuries. Observation would also lead to the belief that certain individuals are much more predisposed to pyæmic action than others placed under similar circumstances. Occasionally, in gun-shot injuries of bones, where no splintering has occurred, but only a small portion of the periosteum has been torn off and the shaft contused by the stroke of a bullet, severe inflammation will follow, the medullary canal become filled with pus, and death ensue from pyæmia. The attention of surgeons has been particularly called to the various circumstances producing inflammation and suppuration of the medullary tissues—osteo-myelitis—in long bones after gun-shot injuries by M. Jules Roux of Toulon.*

Upper extremity.—Fractures of the bones of the arm are well known to be very much less dangerous than like injuries in the corresponding bones of the lower extremity. Unless the bone be extremely injured by a massive projectile, or longitudinal comminution exist to a great extent, especially if also involving a joint, or the state of the patient's health be very unfavourable, attempts should always be made to preserve the upper extremity after a gun-shot wound. In the history of the British army in the Crimea, the recoveries without amputation are shown to be, in the humerus 26·6; radius and ulna, 35·0; radius only, 70·0; ulna only, 70·0, per cent. of cases treated. The proportion of deaths in the cases in which conservative treatment was adopted, was humerus, 8.6; radius and ulna, 2·8; radius only, 7·7; ulna only, 5·2 per cent. Dr. Chenu's returns show a much larger percentage of deaths in the corresponding cases in the French army. Out of 334 cases of fracture of the humerus treated without amputation, 88 died, or 26·3 per cent.; out of 177 cases of both bones of the forearm, 34 died, or 19·2 per cent.; 143 cases of the radius only, 27 died, or 18·6 per cent.; 125 of the ulna only, 16 died, or 12·8 per cent. But so many cases of wounds of the upper extremity are not included in the above figures, from their particular nature not having been recorded by the surgeons in the field, that, had the whole number been available, the proportions stated might have been materially changed. The statistics of the gun-shot fractures of the upper extremity inflicted during the late war in the United States are not yet completed.

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* *Bulletin de l'Académie Impériale de Médecine,* April 24, 1860. See also *Des Amputations consécutives à l'Ostéomyélite dans les Fractures des Membres par armes à feu,* par M. H. Baron Larrey, Paris, 1860; and 'Remarks upon Osteomyelitis consequent on Gun-shot Wounds of the Upper and Lower Extremities,' by T. Longmore, in vol. xlviii. of the *Medico-Chirurgical Transactions,* London, 1865.

The following rules briefly indicate the course of treatment to be adopted in gun-shot fractures of the upper extremity when the general circumstances are such as to admit of attempts being made to preserve the limb. When the bone is much splintered, make an examination by the finger for any foreign bodies or detached pieces of bone and remove them; such partially detached portions, and fragments as are only retained by very slight and narrow periosteal connections, should also be removed; the sharp points of projecting spiculæ should be carefully sawn or cut off;* the wound being extended for this purpose at the most dependent opening if there are two wounds, or a fresh incision being made if only one exists, and it is not in a favourable position for the operation. Wetted lint, or carbolic acid dressing, should then be applied, the limb properly supported, and the cure proceeded with as in cases of compound fracture from other causes (see Fracture).

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* Dupuytren made a division of the splinters of bones broken by gun-shot into three classes: viz. primary sequestra, those directly and completely separated by the force of the projectile at the time of the original injury; secondary sequestra, those retaining partial connections by periosteal, muscular, or other attachments, but afterwards thrown off during the suppurative process; and tertiary sequestra, or portions which become necrosed, their death being either due to the effects of the original contusion, or to prolonged inflammatory action in parts adjoining the seat of fracture. In accordance with this arrangement, surgeons have usually regarded the removal by surgical interference of the primary and secondary sequestra as simply anticipating nature in her work; but it has been stated by some German surgeons as one result of the experience of the Schleswig-Holstein war, that in the majority of comminuted fractures, the removal of splinters retaining any connection whatever with periosteum is not only unnecessary, but often injurious; as is also the practice of sawing off the broken ends of bones projecting from comminuted parts. It is asserted that by proper treatment and under favourable circumstances, such splinters become impacted in the callus, assist in strengthening the new bone in process of formation, and in time unite with the other parts of the bone, so that in this manner a cure is completed without operative interference. No doubt this does happen in some cases, but it is a matter of constant observation also, and the writer believes in the majority of cases, that splinters which have thus become impacted in callus are subsequently discharged with tedious irritation, as if they were so many foreign bodies; and, again, that the removal of jagged ends of broken bones has been very valuable in preventing untoward accidents in their neighbourhood, and thus of favouring union. It is for these reasons that English surgeons generally pursue the practice above recommended.

If the shoulder or elbow-joint be much injured, but the principal vessels and nerves have escaped, the articulating surfaces and broken portions should be excised. The results of excision practised in the shoulder and elbow-joints, especially the former, after gun-shot wounds have been exceedingly satisfactory. Especial attention was first directed on any extensive scale to the practice of resections of these joints, after gun-shot injuries, in the Schleswig-Holstein campaigns, between 1848 and 1851: and Dr. Friedrich Esmarch has published the results in a valuable essay on the subject. Of 19 patients in whom the shoulder-joint was resected, in 12 a more or less useful arm was preserved; and 7 died. Complete anchylosis did not occur in any one instance; and in several the power of motion became so great as to enable the men to perform heavy work. Of 40 patients for whom resection of the elbow-joint was performed, 6 died, 32 recovered with a more or less useful arm, 1 remained unhealed at the time Dr. Esmarch wrote (1851), and in 1 mortification ensued, and amputation was performed.

The cases of resections of joints in the upper extremity during the Crimean war, of which records have been preserved, are comparatively few in number, but the results of the operations were satisfactory. Out of thirteen resections of the shoulder in the English force between April 1, 1855, and the end of the war, there was only one death; eight of these were primary, five secondary, operations. Out of 14 elbow-joint resections during the same period, there were three deaths. The returns of the resections in the French army are less favourable. Out of 45 resections of the shoulder recorded by Dr. Chenu, there were 25 deaths; of four resections of the elbow, all died. During the late war in New Zealand several resections of joints were performed * with remarkably successful results. Resection of the shoulder-joint was performed nine times, and of the elbow-joint twice, and no death occurred.

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* For histories of the cases referred to, and observations on the condition of the patients after their arrival in England, see papers on the subject published by the writer in the *Army Medical Reports*, vol. v. p. 558, London, 1865; and vol. vi. p. 510, London, 1866.

Resections appear from the Washington report before quoted to have been extensively practised during the late war in the United States. The returns are not yet complete, but they show with regard to the shoulder-joint, that the results have been ascertained in 210 primary, and in 298 secondary, resections. Among the 210 primary resections there were fifty deaths, or 23·8 per cent.; among the 298 secondary resections, 115 deaths, or 38·5 per cent. Thirty-six cases of gun-shot fracture of the head of the humerus are stated to have been selected as favourable cases for the expectant plan, the treatment being carried out without resection or amputation. Of these sixteen died, or 54·4 per cent.

The results are reported in 286 cases of resections of the elbow-joint. Of these, 62 terminated fatally, or 21·67 per cent.; in sixteen cases secondary amputation of the arm became necessary. The compilers of the report anticipate that the percentage of mortality will prove to be less when the statistics of this operation are completed.

Thirty-five resections of the wrist-joint during the United States' war are recorded. In 27 of these cases the end of either the radius or the ulna, or the ends of both, were removed, and in some instances shattered fragments of the upper row of carpal bones. In 8 cases the greater part of the carpus was excised. Twenty-six of these cases are reported to have recovered, 2 were followed by amputation, and 3 died. The result in the remaining 4 is not stated. It is remarked that the reports are unsatisfactory in relation to the amount of mobility left in the hand, but further investigations are promised on this point.

Gun-shot wounds of the wrist-joint are usually attended with so much injury to the superficial structures that it seems scarcely possible their treatment by resection can ever under such circumstances produce satisfactory results. Just as extensive laceration of the forearm by destroying the motor power renders a hand useless, so does destruction of the functions of the flexor and extensor tendons by which the wrist-joint is embraced, effect the same result; and a hand that cannot be used is not simply useless, but is generally a painful encumbrance to the possessor. This does not apply to partial amputations, for even though only one or two fingers remain, so long as the power of flexion and extension is retained, they become most valuable: the preservation of a thumb and finger if possible is a most important object to attain. As a secondary operation, after rare exceptional cases of gun-shot wounds of the wrist in which the superficial structures have escaped, there is no reason why resection of the wrist should not be attended with the same excellent results that have attended the operation when performed for conditions of disease.

Lower extremity.—Gun-shot wounds of the lower extremity vary much more greatly in the gravity of their results, as well as in the treatment to be adopted, according to the part of the limb injured, than happens in those of the upper extremity. As a general rule in field-practice, ordinary fractures below the knee, from rifle-balls, should never cause primary amputation; while, excepting in certain special cases, in fractures above the knee, from rifle-balls, amputation is held by most military surgeons to be a necessary measure. The special cases are, gun-shot fractures of the upper third of the femur, especially if it be doubtful whether the hip-joint is implicated or not; for in these the danger attending amputation itself is so great, that the question is still open, whether the safety of the patient is best consulted by excision of the injured portion of the femur, by removal of detatched fragments and trusting to natural efforts for union, or by resorting to amputation. The decision of the surgeon must generally rest upon the extent of injury to the surrounding structures, the condition of the patient, and other circumstances of each particular case. If the femoral artery and vein have been divided, any attempt to preserve the limb will certainly prove fatal.

The femur—the earliest formed, the longest, most powerful, and most compact in structure of all the long bones of the body—can only be shattered by a ball striking it with immense force. But this amount of force a modern rifle-ball possesses at all ordinary distances, and, unfortunately, in almost every instance of compound fracture of the femur by rifle projectiles, we find the bone not merely broken, but extensively comminuted at the seat of fracture, and often fissured for long distances along the shaft. When a patient with a gun-shot fracture of the femur comes under a surgeon's charge, however free from complications and however favourable the case may appear to be, the surgeon knows that the patient will be unavoidably subjected to a wide variety of hazardous circumstances if an attempt to conserve the injured limb be determined upon, owing to the prolonged hospital treatment which is absolutely necessary before a cure can be completed. The treatment, too, is very difficult; for while, on the one hand, the most perfect rest, and as uninterrupted an apposition of the broken portions of bone as possible, are essential for obtaining reunion—on the other, the close connection of the broken bone with the trunk, and consequently the liability to disturbance in all movements of the body, with the necessity for the daily removal of the profuse discharges which follow these wounds, are so many constantly recurring impediments to procuring the quiet so essential.

A considerable amount of attention was specially directed during the Crimean war to the question of the proper treatment of gun-shot fractures of the femur, and expectations were generally held that the advanced experience in conservative surgery would lead to many such cases terminating favourably with preservation of the limb, which previously would have been subjected to amputation. Towards the latter part of the campaign, all the circumstances of the patients were as favourable for testing this practice as they have been in the various revolutionary engagements in Paris. They had equally the advantages of immediate attention, and of all the appliances of the best hospitals close at hand. Yet, in the *Surgical History of the War*, it is shown that only 14 out of 174 cases of compound fracture of the femur among the men, and 5 out of 20 among the officers, recovered with union of bone, or, in other words, without amputation being performed; that those selected for the experiment of preserving the limb were patients where the amount of injury done to the bone and soft parts was comparatively small; and that where recovery ensued, it always proved tedious, and the risks during a long course of treatment numerous and grave. Out of the 174 soldiers just mentioned, 96 were subjected to amputation, and, of the 78 in whom amputation was not practised, 64 died:—of the 20 officers, 10 were subjected to amputation, and, of the remaining 10 not operated upon, 5 died. Amputations of the thigh, however, were very fatal in their results also, the recoveries being stated to be among the men only 34·7 per cent. Among the officers the proportion was rather more favourable. But this percentage includes those cases in which previous attempts to preserve the limb had failed, and, death threatening, amputation was resorted to as a last chance of saving the patient. The number of deaths under the head of amputations was thus increased. On account of this comparatively indifferent success of amputation, resection of portions of the shaft of the femur was sometimes practised; but the records state that no success attended the experiment, every case, without exception, having proved fatal. It is therefore seen from the English experience in the Crimea of the treatment of gun-shot fractures of the femur, that the hopes of conservative practice being the means of preventing amputation were not realised. Of the three modes of treatment, resection was the most fatal; conservative treatment, next; and amputation least fatal. The first was uniformly fatal; the deaths among cases treated without operation were 82 per cent.; the deaths among those treated by amputation, almost hopeless cases included, were 65·2 per cent.

In considering the results of gun-shot fractures of the femur, the situation of the injury is a matter of great importance as regards the chances of recovery, whether without or with amputation. In the *Official History of the Crimean Campaign* this fact is shown in the results of amputation, the recoveries in the upper third being 12·9, in the middle third 40, in the lower third 43·3 per cent. of the cases treated; but the distinction is not made in regard to the recoveries without amputation. Hence no exact numerical comparison can be drawn between the results of amputation and conservative practice in the three main divisions of the thigh in this instance. Dr. Macleod, in his *Notes*, remarks that he has only been able to discover three cases in which recovery followed a compound fracture in the upper third of the femur without amputation; one, that of an officer of the 17th Regiment; the second, of a soldier of the 62nd; and a third, whose regiment is not named. A case, however, was under the care of the writer, not included in the above, nor appearing in the official history of the war; and one, judging from the results described in Dr. Macleod's *Notes*, more fortunate in its issue than at least two of the number he mentions. With regard to the first patient, Dr. Macleod states he has been informed 'that although his limb was in a very good condition when he left for England, the trouble it has since given him, and the deformed condition in which it remains, makes it by no means an agreeable appendage;'* in the second, the fracture was in the lower part of the upper third, and the injury was comparatively slight; in the third, a mass of callus was thrown out which connected the bone, but he died of purulent poisoning and never left the Crimea. In the case which was under the writer's care, the fracture was within the upper third; there is no distortion, and shortening only of 1½ inches: the officer is able to walk or ride without any inconvenience, and competent for all duty.* All the circumstances were most favourable for recovery in this instance; and a consideration of these on the one hand, and the experience of the unfavourable results of amputation in this region on the other, led to the effort to save the limb. A short history of this case will be useful.

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* The officer referred to must have greatly improved in condition after Dr. Macleod wrote, as he was for some time afterwards on active service in India, though he is no longer in the army.

Lieutenant D. M., 19th Regiment, æt. 17, of sanguine temperament, healthy frame, was brought up to camp about 4 A.M., Sept. 9, 1855. He had been wounded in the assault upon the Redan in the upper part of the left thigh, and had been lying by the side of the ditch where he fell thirteen hours. When discovered, he was carried carefully in a soldier's great coat as far as the opening of the trenches, and thence on a stretcher to camp. He was very cold and prostrate on his arrival. The wound in his left thigh had been caused by a ball which had passed out. It entered posteriorly at the fold between the left nates and thigh, three inches from the tuberosity of the ischium; passed forwards, downwards, and outwards, and made its exit seven inches below the trochanter major. The femur was broken in the line of passage of the ball, which, from entrance to exit, appeared to be about six inches. From the trochanter major to the seat of fracture was four inches; to the external condyle on the same side was 15½ inches. The amount of comminution appeared slight, but, from its vicinity to the joint, the great swelling about the limb, and desire to avoid aggravating pain, the precise condition of fracture was not further ascertained. The upper fragment projected forwards, but any attempts at reduction caused great suffering; and some restoratives being given, wet compresses applied to the thigh, and the limb secured against additional movement, the patient was left to rest. At a consultation the following morning, from the patient's age, so favourable for reparative action, his very healthy constitution, and the fact that, the siege being over, full attention could be paid to the case, conservation of the limb was settled to be attempted, and the patient was therefore treated with this view. In addition to the wound just named, he had received an extensive contusion of the right side thigh by the fall of some heavy substance from the explosion which occurred at 1 A.M., after the Russians left the Redan.

There is not space to follow the details of the treatment of this case. The cure was protracted by large and troublesome bed-sores; and attention to these, to the discharges from the wound, and to preserving favourable position, occupied much time and care daily, and caused many changes in the appliances for these objects to be from time to time necessary. On November 4, union had so far taken place that he was able to raise his body from the knee upwards while in bed, without apparent motion at the seat of fracture. On November 15, in consequence of the great explosion at the right siege-train, he had to be carried to another division of the camp; this was effected without harm. In the middle of January he was able to sit in a chair without inconvenience; and on February 22, he left the Crimea for England, being able to walk with the assistance of crutches. Union was then firm; but a slight serous oozing continued from the wound of exit, and there was much stiffness of the ankle and knee-joints from the long-continued constrained position to which he had been subjected. In July, 1856, after his arrival in Ireland, indications of pus collecting manifested themselves at the wound of exit; and Professor Tufnell, on passing a bougie about seven inches in the course of the wound, evacuated a small abscess, and felt a piece of bone trying to make its way to the surface. This was subsequently removed, and, under Mr. Tufnell's able care, the stiffness of the joints gradually disappeared, and he was enabled to return to duty.*

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* This officer is at present holding an important staff-appointment in India.

Dr. Macleod says that, after many inquiries respecting cases of this nature in the hospitals of the other armies engaged in the war, excepting one presented by Baron Larrey to the Société de Chirurgie in 1857, he never could hear of any other but that of a Russian whose greatly shattered and deformed limb he often examined.† It had united almost without treatment. Six cases of recovery without amputation after fracture in the upper third of the femur came from India among 900 invalids for gun-shot wounds consequent on the Sepoy mutiny. In 4 of these cases the patients had good useful limbs; in 2, the consolidation was not complete on the men leaving the invalid hospital, there still being some sequestra to come away from the seat of injury. The number of men who returned after amputation in the upper third was 3. So far as these data go, the proportion of recoveries after gun-shot fracture in the upper third without operation was 1 in 150 of all classes of wounds, and that after amputation was 1 in 300. M. Jules Roux, of the St. Maudrier Hospital, at Toulon, has given a list of no less than twenty-one cases of recovery without amputation after gun-shot injuries of the upper third of the femur, among the soldiers whom he had examined on their return from the Italian war of 1859. In all of them consolidation of the fracture had taken place. We have no data by which we can estimate the proportion of these cases of union to the recoveries after amputation in the same part of the femur.

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* The following is an interesting point in connection with this case, inasmuch as it illustrates how long a time a splinter of bone may remain impacted without causing irritation and then procure an outlet. The opening through which the sequestrum noticed above came away, became firmly healed after its removal. Although the officer has ever since been actively engaged in the duties of a cavalry officer, a great part of the time in tropical service, no symptom whatever occurred to indicate that any other sequestrum remained until the year 1866, ten years after the first was removed. Then some tenderness was felt, a small abscess followed, and another splinter of necrosed bone an inch in length escaped. The opening quickly closed, and its site has remained sound and free from any tenderness ever since.

† *Notes on the Surgery of the Crimean War*, p. 295.

In the war in the United States, out of 32 recorded cases in which amputation was performed in the upper third of the femur, 24 died, showing a mortality rate of 75 per cent.; out of 330 cases in which conservation was practised, 93 recovered, and 237 died, a mortality rate of 71·81, or a trifle more than 3 per cent. in favour of conservative measures. The various figures quoted above tend to confirm the propriety of the practice of conservation, which is generally recommended by military surgeons of the present day, in preference to amputation, for uncomplicated gun-shot fractures of the upper third of the femur.

With regard to gun-shot fractures in the middle and lower thirds of the femur, the experience of the French and English surgeons in the Crimea, and apparently of the surgeons engaged in the late war in the United States also, has tended to confirm the doctrine of the older military surgeons, that many lives are lost by trying to save limbs after injuries in these situations; and that, of the limbs preserved, many are little better than incumbrances to their possessors. In the Italian war of 1859, the practice of trying to save the lower extremities after comminuted fractures in the middle and lower thirds of the thigh appears to have been abandoned in consequence of the experience gained in the Crimea.

So far as the United States' returns have gone, they do not show so much difference between the ratio of mortality when amputation is performed or conservation practised in these situations, as was generally deduced from the Crimean experience on this head. Out of 93 cases of fracture of the middle third in which amputation was performed, 42 recovered and 51 died, showing a rate of mortality of 54·83 per cent.; out of 238 cases in which conservation was practised, 106 recovered, 132 died, showing a mortality rate of 55·46 per cent. The ratios show, therefore, a slightly less fatal result when amputation was performed in the middle third, than when conservation was practised.

Out of 243 gun-shot fractures of the lower third in which amputation was performed, 72 recovered, and 101 died, showing a mortality rate of 57·79 per cent. Here the mortality rate was considerably less when amputation was performed, viz., as 46 to 57¾, than when conservation was practised. Experience so far, therefore, while indicating the propriety of practising conservation in the upper third, inculcates amputation to be the safest practice in gun-shot fractures of the middle and lower third of the femur.

Amputation at the hip-joint, both in the French and English armies, in all instances proved fatal. The two patients who survived the longest in the English army were operated on by Mr. Alexander, afterwards Director-General of the Army Medical Department, at the Alma: one, a soldier of the 33rd Regiment, died at Scutari three weeks after the operation; the second, a Russian, died on the thirtieth day after, from 'extensive sloughing and great debility.'* M. Legouest, of the French army, performed amputation at the hip-joint in the case of a Russian prisoner, and the patient nearly recovered. He died the fourth month after the amputation, and then from the effects of a fall. In the Schleswig-Holstein campaigns, amputation at the hip-joint was performed seven times; one patient only survived, a young man, æt. 17 years, operated upon by Dr. Langenbeck. All the primary amputations at the hip-joint during the Italian war of 1859 proved fatal. A successful secondary case occurred at Verona, the operator being Dr. Neudörfer; and M. Jules Roux has recorded that amputation was performed at the hip-joint six times from the consequences of wounds received during the war in Italy, and that, of these, four were successful. During the late war in the United States there occurred 53 authenticated hip-joint amputations, 34 in the United States' armies, 19 in the rebel armies. These have been divided in the history given of them into four categories; primary, intermediate, and secondary amputations, and re-amputations.† In

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[*] In the surgical history of this war, this statement, which was quoted by the late Mr. Guthrie, in the addenda to his *Commentaries,* is said to be a mistake, on account of the absence (not to be wondered at, amid the confusion of that period) of official records on the subject. Special reports on these cases were obtained at the time from Scutari, and were shown to the writer by Director-General Alexander shortly before his decease.

[†] Circular No. 7, W. D., Surgeon-General's office, Washington, July 1, 1867. 'A Report on Amputations at the Hip-joint in Military Surgery, by G. A. Otis,

the primary cases, 119 in number, the results of which are completely known, the mortality was 94·73 per cent.; in the intermediate, 18 in number, the mortality was 100 per cent.; in the secondary, 9 in number, 77·78 per cent.; in the re-amputations, 7 in number, only 42·85 per cent. M. Legouest, in an essay published in the *Memoirs of the Society of Surgery*, at Paris, maintains that amputation at the hip-joint should be reserved for cases of fracture with injury to the great vessels, and that where the vessels have escaped, resection should invariably be performed. He also inculcates the doctrine not to perform immediate *primary* amputation at the hip-joint in any case; but, even in the severest forms of injury, to postpone the operation as long as possible.*

In fractures of the leg, where neither the knee nor ankle-joint are implicated, the results of conservative attempts have been more favourable. In the English army in the Crimea, the recoveries without amputation being resorted to were, in fractures of both bones, 18·9; tibia only, 36·3: fibula only, 40·9 per cent. When a gun-shot fracture of the tibia extends into the knee or ankle-joint, opening the capsule, amputation is held to be the rule of treatment. In rare instances recovery without amputation has followed injuries where one or other of these joints has been believed to have been thus opened; but, when the interior of either of these articulations is penetrated under such circumstances, the risk to life in trying to preserve the limb must be very great, while the advantage of capacity for motion, if life be preserved, must always be doubtful. Conservative

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Assistant-Surgeon and Brevet Lieutenant-Colonel, U. S. Army.' This report contains a very complete historical summary of the subject, as well as an account of the individual cases which occurred during the United States' war. The report is beautifully illustrated by lithographic and chromo-lithographic drawings.

* A committee was appointed by the Surgical Society of Paris to examine and report upon this essay of Dr. Legouest on 'Coxo-femoral Disarticulation for Gun-shot Wounds.' Baron Larrey drew up the report, which will be found in the 5th vol. of the *Mémoires de la Société de Chirurgie*, 1860. It confirms the principle laid down by Dr. Legouest, excepting only those cases of fracture where the mutilation of the limb from a heavy projectile has been so great as to partly separate it from the pelvis, and those in which there has been simultaneous lesion of the crural vessels and femur near the pelvis, with extensive laceration of the surrounding tissues.

Mr. Otis concludes that the experience acquired in the war of the Rebellion in the United States indicates that these maxims and rules are too unqualified and absolute.

practice in such cases can only hold out a chance of success under the most careful and refined surgical treatment, with every means constantly at hand, as well surgical appliances as nursing, and under the most favourable sanitary conditions—combinations which the circumstances of warfare rarely allow.

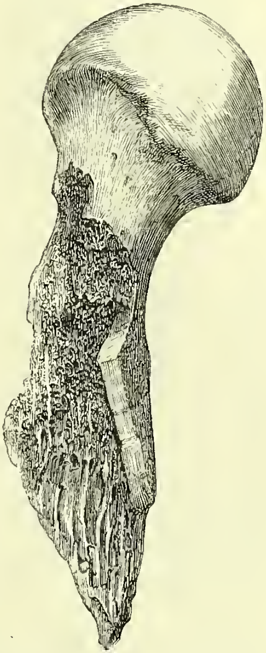
In the treatment of fractures of the leg where it has been determined to seek union, the same remarks apply as those made above in respect to fractures in the upper extremity. In wounds of the foot it is especially necessary to remove as early as possible all the comminuted fragments of the bones injured; or tedious abscesses, and much pain and constitutional irritation, are likely to ensue.

One case of excision of the head, neck, and trochanters of the femur for gun-shot injury in the Crimea recovered. Fatal results followed five other cases in which similar excisions were practised by English surgeons during this war, as they had in all previous excisions of the hip-joint for gun-shot injuries. The successful operation was performed on August 19, 1855, by Dr. O'Leary, the same day that the wound was received. The patient died ten years afterwards of phthisis. He never regained the power of using the limb without support, but required the aid of a crutch and stick to enable him to walk. In the Schleswig-Holstein campaign a similar operation was performed three weeks after the injury, but the patient died from pyæmia. Dr. Neudörfer excised the hip-joint four times for gun-shot injuries after the Italian campaign of 1859. The operation was not successful in any one instance. Three of the patients died, the fourth survived, but only after secondary amputation at the hip-joint. The results of hip-joint excisions in the United States have been more successful. Out of 31 such excisions, 4 have recovered, leaving 27 which have terminated fatally.

It is a curious fact, in a historical point of view, that Sir Charles Bell proposed excision of the upper fragment in 1818 at Brussels in the case of François de Gay, who had been wounded nineteen days before at Waterloo, and on whom Mr. Guthrie successfully practised amputation at the hip-joint the next day instead. The reasons for his advice are preserved in some manuscript notes made about the time of the occurrence, in a diary presented to the Army Medical School by Lady Bell, his widow. The chief points are the following :—' My proposal is to extract the head of the bone, and do no more. Mr. Guthrie's proposal is to amputate the thigh at the hip-joint.

If the bone be taken out, there is a great cavity and suppuration certainly; but by this means the shock and violence will be saved. I fear the shock of so great an injury, especially as now the wound cannot be cut off (alluding to its extent and sloughy condition) and its injury must be superadded to that of the incisions. The man will readily allow of my proposal, but not of G.'s. However, next day he said he would consent. In the meantime I was forced home by business,' &c. The broken and separated head and neck of the femur in Guthrie's case is preserved in the Museum of the Army Medical Department at Netley, and, both from its intrinsic interest, and because it almost exactly corresponds with the upper fragment in the Crimean case in which resection was successfully performed, a drawing of it is appended.

FIG. 39 *a*.



Head, neck, and part of shaft of femur, forming the upper fragment in the case for which Mr. Guthrie successfully amputated at the hip-joint after the battle of Waterloo.*

Direct gun-shot wounds of the *knee-joint* are of the most hazardous nature. The admission of air by a tunnelled and contused track into so large and convoluted a synovial sac as that which lines the interior of this important articulation, and the subsequent effects of the inflammatory action induced by the injury, constitute their chief serious features when simple penetration of the joint has occurred. But penetration, or perforation, by a bullet rarely occurs without serious concomitant injury to the cartilaginous and bony structures which are comprised in this complicated articulation. The extent of the mischief which may be effected by a bullet entering the knee-joint, even when not possessing force enough to pass through the articulation, is well shown in the following drawing (Fig. 40).

Although this joint is so little covered by soft tissues, and consequently so easy of access, mistakes in diagnosis frequently occur in wounds of it by small projectiles, especially when the injuries have not been examined soon after their infliction. Deflection and escape of bullets, circuitous courses pursued by them, escape of fluid from the bursa beneath the ligamentum patellæ, have led to the supposition of the interior of the joint having been opened when no penetration has occurred; and equally in other cases, the joint has been presumed to have escaped penetration, until symptoms arising subsequently have exposed the error.

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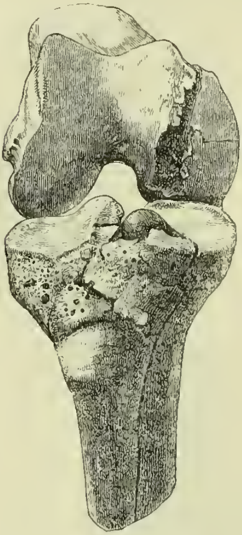
* Spec. No. 2,929, in the Army Medical Museum, at Netley.

Fig. 40.



Upper end of tibia, and lower extremity of femur, shattered by a bullet which has entered the joint, and become lodged near the spinous process of the articular surface of the tibia.*

The proper treatment of a penetrating gun-shot wound of the knee-joint, when the diagnosis has been satisfactorily established, is generally a matter of serious doubt and difficulty. The necessity of amputation, when the articulating ends of either or of both of the two principal bones are broken in addition to the joint being penetrated, has hitherto been generally recognised and acted upon in field practice. But the ratio of mortality in amputations at the lower third of the thigh, has frequently led surgeons to resort to other modes of treatment. Resection has been tried, but with comparatively little success, in field practice. It failed altogether in the Schleswig-Holstein campaigns, and in the Crimea. Three cases out of eight operated upon by Dr. Neudörfer of the Austrian army, during the Italian war of 1859, recovered. Out of eleven resections during the United States' war, the Surgeon-General's report states all but two terminated fatally, and in one of these a doubt is expressed in the report as to its authenticity. Disarticulation of the leg at the knee was frequently employed by surgeons of the French army in the Crimea, in gun-shot wounds involving the joint, when the femur had escaped injury. Out of sixty-nine cases of knee-joint amputation, however, only six survived. There were only seven instances of this operation in the British army, but out of these three recovered. Freely incising the joint has been tried, but has been only occasionally attended with success; one case treated in this way, in the late New Zealand war, recovered. A series of cases of gun-shot wounds of the knee were similarly treated by Surgeon J. Moses, of the United States' army.* The official report, from the Surgeon-General's office, gives no encouragement to practise this treatment. It refers to six fatal cases, which had been treated by free incisions by Surgeons Moses, Bellanger, and Lidell, and mentions that the records contain a score of similar examples. Professor Langenbeck strongly advocates conservative treatment of gun-shot wounds of the knee. There is hardly a case, he says, although with fractured bone-ends, that may not be cured by conservative treatment. Amputation, or resection, he reserves for cases where fragments of bone are actually severed, or where shattering of the bone-ends are complicated with considerable tearing or loss of soft parts. He considers it of the highest importance for success that the joint should be rendered immovable by rigid plaster of Paris bandages from the moment of injury to the completion of cure. Ice for the first three or four days, then lint dressings dipped in permanganate of potash, or carbolic acid, are the other applications recommended by him. During the Bohemian war of 1866, out of eighteen cases of gun-shot wounds of the knee, eleven were cured by conservative treatment. Dr. Langenbeck mentions that the experience of that war has shown that men suffering from these wounds can be transported by railway with proper appliances without any ill results.

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* Spec. No. 1481, in the Army Med. Museum at Washington.

Gun-shot wounds of the *ankle-joint* were also, until a comparatively recent date, held by all military surgeons to involve the necessity either of removal of the foot at the joint or of amputation above it, according to the extent of the injury. Resection of this joint was not considered an operation suitable for military practice. The aggravation of the original injury from the effects of transport from the field to successive hospitals; the tedious process of repair in case of resection being practised; the unceasing and minute attention required during the treatment; the many hazards to the patient during its course; the nature and disposition of the structures surrounding the articulation; the great uncertainty regarding the ulterior results of this plan of treatment, when circumstances might admit of the necessary care and attention being given; all these considerations led military surgeons to resort to amputation as the most advisable proceeding, both with regard to the safety of the patient's life and to his subsequent condition in regard to power of progression. There was no case of resection of the ankle-joint, properly so called, in either the English or French armies during the Crimean war. Professor Langenbeck, however, has practised resection of the ankle-joint in cases of gun-shot injuries with remarkable success, and has done much to introduce it as one of the regular operations of military surgery in future wars. This distinguished surgeon, indeed, considers that resection of the ankle-joint ought to be as much practised as resection of the shoulder-joint, and that amputation ought only to be resorted to when the soft parts have been very largely lacerated, or when the arteries and nerves have been torn away. Professor Langenbeck practised resection of the ankle-joint in five cases for gun-shot wounds sustained in the German-Danish war of 1864. Only one death occurred among them, and this was from hospital gangrene. All the resections were done sub-periosteally. Fixation was obtained by the immediate application of fenestrated gypsum bandaging. In one of these cases, in which a bullet entered at the internal malleolus and made exit at the external malleolus, notwithstanding altogether two inches and a half of the articulating portions of the tibia and fibula and astragalus were removed, the patient recovered with anchylosis, but *without any shortening*, owing to the extensive formation of new bone. In the late Bohemian war of 1866 Dr. Langenbeck performed eleven sub-periosteal resections of the ankle-joint, and out of these nine recovered with conservation of a useful foot. All the operations in these cases were secondary. With regard to the war in the United States, the Surgeon-General records, in the before quoted circular No. 6, that there were eight excisions of the tibio-tarsal articulation, and that of this number five died, and the conclusion put forth with regard to ankle-joint wounds is, that 'the formal excisions are rarely successful.' Dr. Langenbeck strongly insists on complete immobilisation of the parts involved in the operation being indispensable for a successful result. It is not stated whether this formed part of the treatment adopted in the United States' war.

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* See *Amer. Journal of the Med. Sciences,* vol. 47, p. 324.

AMPUTATION.

It is not necessary to refer at much length to the question which was formerly disputed upon, the advantages of *primary* as compared with *secondary* amputation in gun-shot wounds; for military surgeons, whether acting at sea or on land, have practically determined the subject. For a long time the directions of John Hunter, that amputation should not be performed until the first inflammation was over, based on the argument that the 'amputation is a violence superadded to the injury, and therefore heightens the danger,' and that this danger is aggravated in the instance of a man labouring under mental agitation, as on the field of battle, had great weight among English surgeons; but experience has led to a different practice. The greater success of primary amputation appears to be attributable to the facts that a contused and mangled limb is a constant source of accumulating irritation; that the exciting circumstances connected with battle lead a man to bear with courage at an early stage what subsequent suffering and anxiety may render him less willing to submit to; that a soldier, when first wounded, is most probably in stronger health than he will be after hospital restraint and confinement; that though the amputation is a violence, it is one the patient is likely to submit to with resignation, knowing that it is performed to remove parts which, if unremoved, will destroy life; and lastly, because the operation takes away a source of dread which must weigh down the sufferer so long as it is impending. The present practice has resulted from testing both modes of amputation. Mr. Guthrie showed, from the experience of the Peninsular war, that the loss in secondary amputation had constantly exceeded that from primary amputations in both the upper and lower extremities. More recent observations in both English and French campaigns have confirmed this result. Dr. Scrive records that the experience of the French army in the Crimea showed the success of primary amputation sometimes exceeded by two-thirds that of secondary amputation. He excepts amputations at the hip-joint, and cites, as his reason for this exception, that in nine cases where the hip-joint amputation was performed primarily, death followed the operation a few instants or a few hours afterwards; while in three cases which he witnessed, where the amputation was consecutive, one lived five, another twelve, and the third twenty, days. In respect to the particular time at which primary amputation is to be performed, the general practice of the present day is, when the operation is inevitable, to perform it as soon as it can be done, provided the more intense effects of 'shock,' where it has supervened on the injury, have passed off; and this practice generally accords with the feelings of soldiers, who not unfrequently press the surgeon for an early turn in being relieved from the suffering resulting from a shattered limb. In the cases where primary amputation is to be performed, a further reason given by Dr. Scrive for the operation being done on the same day that the wound is received is, that chloroform acts then so much more benignantly and readily; while, on the following day, or day after, traumatic excitement becomes very energetic, and considerable resistance is afforded to its influence by wounded men, and longer time and a much larger dose of the chloroform are required to produce a state of anæsthesia. If only a moderate amount of 'shock' exist, this does not appear to be a sufficient reason for delaying amputation; for a moderate exhibition of stimulus, and a few consolatory words, will generally remove this; and even though some faintness, pallor, and depression remain, no ill consequences ensue. Indeed, in the Crimea, primary amputations were repeatedly performed where shock had not wholly disappeared, and no harm resulted from the practice. The introduction of chloroform, by its negative operation of preventing pain or alarm, and by its positive action as a stimulus, has done much to remove many of the objections which were urged by John Hunter against early amputations after gun-shot wounds. If collapse be intense, more than is accounted for by the wound to the extremity, suspicion will be excited that some internal injury has been also inflicted, and delay will be necessary for further observation of the patient. When active operations are proceeding, and it is necessary to carry the wounded to any distance, the advantages of early removal of shattered limbs are obvious, especially when means of rendering the limbs immoveable during the transport are defective, or the transport itself has to be conducted over rough roads or in unsuitable vehicles, and the hopes of success from conservative treatment are thereby reduced almost to zero.

SECONDARY HÆMORRHAGE.

Army surgeons meet in practice with secondary more frequently than primary hæmorrhage in gun-shot wounds. It may arise in several ways. Sometimes it results from the coagulum being forced out of an artery in which hæmorrhage had previously been spontaneously averted by the ordinary natural process, this accident being consequent upon muscular exertion or increased impulse of the circulating system from any cause. This occurrence in the bottom of a deep wound will be often found to be a very troublesome complication. Sometimes an artery, which did not appear to be injured in the first instance, ulcerates or sloughs; or, without direct injury, a vessel may become involved in unhealthy deterioration of the wound, and give way; or in a granulating wound general capillary hæmorrhage may be excited by stimulus of any kind, such as venereal excitement or excess in drinking; or the coats of the vessel may ulcerate under pressure from a detached fragment of bone or from some foreign body; or the artery may be accidentally penetrated by the end of a sharp spiculum. Secondary hæmorrhage has been said to arise from increased arterial action, from the first to the fifth day; from sloughing, the effects of contusion, from the fifth to the tenth; from ulceration, to any more distant date.

If we could compare all the cases of hæmorrhage which occur, secondary would, perhaps, statistically appear less dangerous than primary hæmorrhage; for the latter, when happening from large vessels, must be very generally fatal, while, when hæmorrhage occurs in them secondarily, the collateral branches have become partially adapted to the interruption of the flow of blood through the regular channel. Moreover, the larger arteries, when once filled with coagula and well contracted, fortunately do not frequently yield to the impulse which serves to produce secondary hæmorrhage in vessels of smaller calibre.

The rule of treatment holds good in secondary as in primary hæmorrhage — the bleeding vessel must be secured at the wounded part whenever practicable, and it must be tied both above and below the line of division, taking care to ascertain that the spot where each ligature is applied is sound. Hæmorrhage from general oozing, from sloughing, and other causes. must be treated on the general principles applicable in all such cases. (HÆMORRHAGE, Vol. I.)

WOUNDS OF NERVES.

Temporary paralysis from indirect contusion of nerves during the passage of a projectile is not unfrequent. Complete loss of power of motion and sensibility occasionally follows gun-shot injuries, and generally indicates direct stroke, perhaps complete division, of nerves. After a time there may remain only modified deprivation of sensibility, partial loss of muscular force, and diminished power of resisting cold, with or without pain; and these symptoms may either be the result of contusion, together with the effects, perhaps, of inflammatory action, or of partial division. Atrophy of tissues and contractions of muscles are common remote results of injuries to nerves from gun-shot, and often lead to soldiers being disabled for further service. Occasionally, after severe injuries, the functions of sensation and power of motion gradually but slowly return, in some instances with ultimate perfect cure, but mostly with a certain amount of impaired power of resisting rapid alternations of temperature, especially cold.*

When a foreign body is lodged in or among nerves, it may induce tetanic symptoms of a fatal character, or great irritation and intense pain may result; and unless the source of these latter symptoms can be found and removed, if in a large nervous trunk of one of the extremities, they will sometimes lead to the necessity of amputation. The gun-shot injuries which cause division of large nerves are usually attended with so much destruction of other parts, that the question of amputation has scarcely ever to be considered in reference to lesions of nerves alone.

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* During the war in the United States, under orders from Surgeon-General, Dr. Hammond, in the year 1863, a number of patients, labouring under gun-shot wounds and injuries of nerves, were collected and treated in a special hospital, in Philadelphia. These patients are described as having included representatives of every conceivable form of nerve injury, from shot and shells, sabre cuts, contusions, and dislocations. The results of the observations at this hospital have been published in a small volume, entitled *Gun-shot Wounds and other Injuries of Nerves*, by S. W. Mitchell, M.D., G. R. Morehouse, M.D., and W. W. Keen, M.D.; Philadelphia, Lippincott & Co., 1864.

TETANUS.

One cause of fatal termination in gun-shot wounds is tetanus. It is generally believed that the proportion of deaths from this source is greater after actions in tropical climates, and that exposure to the night-air in such regions has some special effect in producing them. The most common cause appears to be, however, the local injury to nerves, already mentioned, producing irritation along their course, and so leading to some morbid condition of the ganglionic portions of the motor tracts of the spinal cord. In the Crimean campaign, the proportion of tetanus was remarkably small as compared with former wars, being, according to the returns, only 0·2 per cent. of the number wounded. Dr. Scrive records that not more than thirty cases of tetanus occurred among the French wounded during the whole Crimean war, and this would show a somewhat less ratio even than in the British army. Dr. Stromeyer records only six cases of tetanus among 2,000 wounded in the campaign of 1849 against the Danes. Three of these, in which the disease assumed a chronic form, recovered. Warm baths and opium were the remedies in the successful cases. Three hundred and sixty-three cases of tetanus were reported during the war in the United States, and of these the Surgeon-General's report states 336 terminated fatally. Of the 27 recoveries, the disease was of a chronic form in 23. In the four remaining cases, the symptoms were very grave; in two of them recovery took place under the use of opiates and stimulants; in the other two, after amputation of the wounded parts.

Three cases of tetanus occurred to the writer, in the Crimea, after gun-shot wounds: all proved fatal. In one there was a severe fracture of the ischium and injury of testicle by grape-shot. In a second, a rifle-ball entered just above the left knee, and lodged. Eight days after the injury, an abscess was opened near the tuberosity of the ischium, and the ball was removed from that spot. The same day tetanus set in, and the patient died three days afterwards. The ball had injured the sciatic nerve, which was found to be reddened superficially, while the neurilema also, under an ordinary magnifying-glass, showed indications of inflammation. A piece of cloth was found lying midway in the long sinus-like wound made by the ball. In a third, the bullet passed through the axillary region. The patient progressed favourably for some days, when tetanic symptoms appeared, and under these he sank. At the post-mortem examination, some detached pieces of woollen cloth were found lying entangled among the axillary plexus of nerves. Twenty-one cases altogether supervening on gun-shot injuries are shown in a table in the Crimean records. Of these, ascertained injuries to nerves by projectiles, or division of nerves by amputation, occurred in eleven cases; three followed compound fractures, and seven flesh-wounds. The average period at which the tetanic symptoms appeared was eight days and a half after the receipt of the injury; their duration prior to death, three days and a half. One case only recovered: a soldier of the 93rd Regiment, wounded in the right buttock by a shell-explosion. A fragment nearly a pound in weight was removed soon after the injury. Seventeen days after, trismus set in, when a further examination of the wound led to the discovery of an angular fragment of shell which had been previously overlooked. It was deeply lodged, and resting on the sciatic nerve. On removing this, which weighed eighteen ounces, the sheath of the nerve was seen to be lacerated to nearly one inch in extent. Calomel and opium were now given, salivation appeared three days afterwards, the trismus subsided, and the man gradually convalesced.

Beyond the extraction of any foreign bodies which may have lodged, as in this last case, it is not known that there are any indications for special treatment of tetanus as occurring after gun-shot injuries. The employment of woorali has again been brought into notice by its successful administration by M. Vella of Turin, in the case of a French sergeant wounded by a musket-ball which lodged in the metatarsus of the right foot, on the 4th of June 1859, at the battle of Magenta. The projectile was extracted three days after his admission into hospital at Turin, on June 10, and tetanus set in three days afterwards. But the woorali failed in two other cases; and it is has yet to be determined, should it be found to possess any peculiar power over tetanic spasm, to what class of cases its properties are applicable. The Surgeon-General's report, before quoted, states that its value as a curative agent was not tested in the cases of tetanus which occurred in the United States during the war. (See TETANUS.)

Hospital Gangrene, a common disease of wounded soldiers, when circumstances of war lead to over-crowding in ill-ventilated buildings, and to deficiency in the proper number of attendants for securing personal cleanliness and purity of atmosphere, often associated with inferior diet; and Pyæmia, a frequent cause of fatal termination after gun-shot fractures, injuries of joints, and other suppurating wounds, especially under the influence of circumstances like those above named, are treated separately under their respective heads.

Anæsthesia in Gun-shot Wounds.

The complete applicability of chloroform as an anæsthetic to injuries caused by gun-shot is now generally established. Ether is still believed by many surgeons in the United States to be more free from danger than chloroform. It is stated in the Surgeon-General's report, that the returns of 23,260 surgical operations, performed on the field or in general hospitals during the late civil war, showed that chloroform was used in 60 per cent., ether in 30 per cent., and a mixture of the two in 10 per cent.; and further, that at the general hospitals, the greater safety of ether as an anæsthetic was commonly conceded.*

The first opportunity of testing chloroform largely as an anæsthetic agent in military surgery occurred in the Crimean war, and a long report on the subject will be found in the *Official Medical and Surgical History of the Campaign*. The general tenor of this report is to curtail the use of chloroform—in minor operations on the ground of occasional bad results, even when the drug is of good quality and properly administered, or, in cases where the shock is very severe, on the ground that such do not rally, owing to the depressing effect of the drug, after the anæsthesia has gone off; or in secondary operations, from the systems of the patients having been much reduced by purulent discharges. But from the report it appears that only one patient died from the effects of chloroform, and in this instance Professor Maclagan, of Edinburgh, to whom a portion was forwarded for examination, reported the drug to be 'acrid and nauseous when inhaled,' and 'totally unfit for use.' On the other hand, Dr. Scrive, chief of the French Medical Department in the East, has written in his *Relation médico-chirurgicale de*

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* *Circular* No. 6, p. 87.

la Campagne d'Orient, p. 465: 'De tous les moyens thérapeutiques employés par l'art chirurgical, aucun n'a été aussi efficace et n'a réussi avec un succès aussi complet que le chloroforme; jamais, dans aucune circonstance, son maniement sur des milliers de blessés n'a causé le moindre accident sérieux;' and more recently, Surgeon-Major M. Armand has written: 'During the Italian war chloroform was as extensively used, and was as harmless, as in the Crimea. I never heard of an accident from its use.' During the late civil war in the United States seven deaths were ascribed to the use of chloroform; at the same time the Surgeon-General's report mentions that the returns indicate it was administered in not less than 80,000 cases.*

At the commencement of the Crimean war the Inspector-General at the head of the British Medical Department circulated a memorandum 'cautioning medical officers against the use of chloroform in the severe shock of serious gun-shot wounds;' but as far as chloroform was available, it was used by many medical officers from the commencement of the campaign, and its employment became more general as the campaign advanced. It was constantly used in the division to which the writer belonged throughout the war, and no harm was ever noticed from its use, while certain advantages appeared especially to fit it for military surgical practice. So far from adding to the shock of such cases as an army surgeon would select for operation, the use of chloroform seemed to support the patient during the ordeal; and the writer has several times seen soldiers within a brief period after amputation for extensive gun-shot wounds, and restoration to consciousness, calmly subside into natural and refreshing sleep. One reason for not using chloroform in the Inspector-General's caution was, that the smart of the knife is a powerful stimulant; but 'pain,' it has been remarked by a great surgeon, 'when amounting to a certain degree of intensity and duration, is itself destructive,' and there can be little doubt that the acute pain of surgical operations, superadded to the pain which has been endured in consequence of severe gun-shot fractures, has often, where chloroform has not been used, intensified the shock and led to fatal results. In civil surgery, statistical evidence has demonstrated that the mortality after surgical operations has lessened since the use of chloroform; and it is believed the same result would be shown, if opportunity existed, in army practice. In the report of a case in the Crimea, instancing, perhaps, the greatest complication of injuries from gun-shot of any which recovered, Dr. Macleod remarks casually in his *Notes*, p. 265, 'This amputation was of course done under chloroform, otherwise it is questionable whether the operation could have been performed at all, the patient was so much depressed.' Mr. Guthrie, in the Addenda to his *Commentaries*, remarked, from the reports and cases which had reached him, that chloroform had been administered in all the divisions of the army save the second, and had been generally approved; and that the evidence was sufficient to authorise surgeons to administer it even in such wounds as those requiring amputation at the hip-joint. The late Director-General Alexander amputated in three instances at the hip-joint after the battle of the Alma under chloroform —two on the 21st, and one on the 22nd September—and all these lived to be carried on board ship on the latter-named day, and two, as before stated, lived several weeks. The absence of increased shock from pain during the amputation very probably enabled the patients to withstand the fatigue of removal to the coast, and embarkation on board ship.

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* *Circular* No. 6, p. 87, where brief abstract reports of the seven fatal cases above referred to may be found.

It must frequently happen in military practice that several operations have to be performed in rapid succession on the same person, from necessity of a speedy removal of the wounded; and, moreover, from the number of cases which are suddenly thrown on the care of the army surgeons after a general engagement, it must frequently occur that the diagnosis of a case is more or less doubtful. In such instances, the use of chloroform, by diminishing pain and preventing shock, and thus giving the opportunity of more accurate examination of parts, becomes particularly valuable in army practice. After the battles of Alma and Inkermann, when orders were given to remove the wounded as soon as possible, the first-named consideration frequently occurred. The case of Sir T. Trowbridge is quoted by Mr. Guthrie. This officer had both feet completely destroyed by round-shot at Inkermann, and it was necessary to amputate, on one side at the ankle-joint, on the other in the leg: the use of chloroform enabled the two operations to be performed within a few minutes of each other with perfect success. In illustration of the second casualty, the following, which happened to the writer at Alma, may be named. A man of the Grenadier company of the 19th Regiment had a leg smashed by round shot. It was a question whether the fracture of bone extended into the knee-joint. Two superior staff-surgeons were near; a hasty consultation was held, and it was decided that the probabilities were in favour of the joint being intact. Amputation was performed, and the tibia sawn off close to the tubercle. It was then rendered evident that there was fissured fracture into the joint. As soon as the man had recovered from the state of anæsthesia, the necessity of amputation above the knee was explained to him, and he readily assented. This was shortly afterwards done, and the man recovered without any unusual symptoms, and was invalided to England. It is not likely, without chloroform, in a doubtful case of this kind, that the chance of saving the knee would have been conceded.

In the British army in field operations chloroform has generally been applied by simply pouring it upon lint. The chief objection against this in the open air is probably the waste which is likely to be occasioned. In the Confederate States, during the late war, it became necessary to economise the use of chloroform to the utmost, owing to its extreme scarcity and very high cost. Under these circumstances, Professor Chisholm invented a small metal inhaler, fitted for insertion into the nostrils, through which alone the chloroform vapour was inspired, while the mouth was left free for breathing atmospheric air. All waste from evaporation, even in the open air, was avoided by the use of this instrument.* Dr. Scrive said it always appeared to him most advantageous to use a special apparatus, as well to measure exactly the doses, as to guarantee a proper amount of mixture of air; and that, although he never saw a fatal result, he had several times seen excess of chloroformisation from the use of lint rolled up in the shape of a funnel. The instructions which he gave were, not to pass beyond the stage of strict insensibility to pain, never to wait for complete muscular relaxation; and to this direction being carried out he attributes the fact that no death occurred from chloroform in the French army in the Crimea. With regard to ether, the quantity required to produce anæsthesia—from four to eight ounces—renders the use of this agent almost impracticable in extensive army-operations in the field.

THOMAS LONGMORE.

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* Dr. Chisholm's Chloroform Inhalers have been manufactured by Messrs. Weiss, of the Strand.

INJURIES OF THE HEAD.

Wounds of the Scalp. Contusion of the Bone.

It has been thought advisable, for practical purposes, to treat of these injuries together, as they are often combined in civil life; and what appeared a simple wound of the scalp is ultimately not unfrequently found to have been complicated by much more serious mischief—contusion of the bone.

Of the various forms of scalp wounds occurring in daily life, wounds produced by heavy blows, or those in which flaps have been more or less extensively detached, are the most common. Such wounds are, for the most part, accompanied by bruising of the soft parts; but it not unfrequently happens that these bruised wounds of the scalp present the appearance of a clean cut, and look exactly as if they had been produced by some sharp instrument. These flap wounds are more common about the scalp than in any other part of the body, and it is in this region, too, that the most extensive wounds of this kind are generally met with, the greater part of the skull being at times uncovered, and even the ears torn away.

Bruised wounds of the scalp are to be treated like common incised wounds, and in many instances they heal just as readily.

Neither is there, in the present day, any question as to what is to be done with flap wounds of the scalp. After careful cleansing of both surfaces of the wound, the flap, however extensive, is to be replaced, and maintained in position by strips of plaister, compresses, and a bandage. Sometimes a suture, here and there, may be necessary; but sutures must be sparingly used about the scalp, and great care must be taken not to include any part of the occipito-frontalis.

Flap wounds of the scalp, of the largest size, are not unfrequently healed within a few days. Occurring, as most of these flap wounds do, by the rending of the loose cellular tissue under the occipito-frontalis, they carry with them a rich supply of blood-vessels; and hence the reason why these flaps so seldom slough, and why they so readily heal.

The bone of the skull being exposed makes no difference as to the plan of treatment; for flap wounds, with extensive exposure of the bone, often heal without a single drawback, and that in cases where such a result appeared almost hopeless.

The wound may, however, not heal by first intention; and, under such circumstances, either granulations spring up from the surface of the exposed bone, or thin, almost imperceptible, scales of bone are thrown off, and union by second intention follows.

Hæmorrhage in scalp wounds is seldom very troublesome. Both ends of the divided vessel can, for the most part, be readily secured, or pressure may be established on the main trunk, at some distance from the wound. In a wound of the lower part of the temporal fossa, hæmorrhage from the deeper vessels may, however, be very difficult to deal with; and in such a case, should the bleeding recur and become dangerous, notwithstanding all our local means, the question of applying a ligature to the external or to the common carotid artery may arise.

Wounds of the scalp, even of the most trifling nature, are not unfrequently followed by inflammation of an erysipelatous character, affecting sometimes the skin only, but much more commonly the loose cellular tissue under the occipito-frontalis muscle.

If erysipelas alone exist, the local treatment is to be of the simplest kind. The frequent lancet-puncturings, so strongly advocated some few years back, are not necessary; they are exceedingly painful, and they certainly do not lessen the duration of the disease.

Diffuse cellular inflammation of the scalp first shows itself by slight puffiness, without any redness of the skin, in the neighbourhood of the wound; and this local indication, if not ushered in, is soon followed by general symptoms—feverishness and rigors. An outpouring of lymph subsequently takes place into the meshes of the loose cellular tissue, and then more or less induration and great thickening of the scalp, which, when cut into, presents a brawn-like appearance. Unchecked, this form of inflammation soon leads to extensive sloughing, and large portions of the cellular tissue are rapidly destroyed.

On the first appearance of puffiness around a scalp wound, a free exit should be given to the effused fluid, and for this purpose the adherent lips of the wound ought at once to be separated. In large flap wounds, however, it is seldom necessary to destroy all the adhesions; a free separation of the lips of the wound at different points is, in most cases, all that is necessary, and then a warm poultice or fomentations should be applied. Should the effusion spread notwithstanding, the system of free puncturing may be adopted with great advantage, and in the more threatening cases incisions will be absolutely necessary. In such cases, the essential point is that the knife should be carried freely down to the bone; and as to the length of the incision, it is better that it should not be extensive. Limited incisions answer every purpose; and they lessen the danger of hæmorrhage, which, in persons of broken-down constitution, may become a matter of vital importance.

Such incisions, provided the general condition of the patient be good, will, in the great majority of cases, prevent any very extensive sloughing of the cellular tissue of the scalp. In some cases, however, extensive sloughing of the cellular tissue does take place, and the tendon of the occipito-frontalis muscle and the pericranium may become involved; but the scalp itself very rarely perishes. This is easily accounted for by the peculiar distribution of the arteries in this region, the trunks and main branches of which here all lie immediately under the skin. And occasionally, to add to the difficulties, a large arterial trunk is laid open by ulceration, and hæmorrhage ensues, the source of which, owing to the blood accumulating under the detached scalp, it may at first be difficult to make out.

With proper management, it is surprising, notwithstanding all this, to see how well a case of this kind may do. The sloughs separate, but the extensively-detached scalp, loose and bag-like, being kept alive by its vessels, soon re-adapts itself to whatever structures may be left, and ultimately becomes firmly adherent to them.

The general treatment, both in erysipelas and in diffuse cellular inflammation of the scalp, must be of the most generous kind. Tonics and diffusible stimulants must be resorted to at a very early period; and it will be advisable also freely to administer such stimulants—brandy, wine, &c.—as the patient may have been accustomed to.

A simple blow on the head, with or without a scalp wound, may sooner or later lead to mischief about the bones of the calvaria. Sometimes the diseased action thus set up ends in hypertrophy of the bones; this may go on for years, and the calvaria thus become enormously thickened. Of this there is a well-marked example in the Museum of the Royal College of Surgeons. In the vault of this skull the bones are, in some parts, no less than eleven lines in thickness.

Again, the diseased action thus set up may lead to caries or necrosis of the calvaria. And here the disease may be limited to the original seat of the injury, or it may spread far and wide, affecting either one or both tables of the bones. In some cases even the mischief has spread over the whole vault of the skull. Specimens of extensive disease, limited to the outer parts of the calvaria, and caused by a simple blow, exist in the Museums of the Royal College of Surgeons and of St. George's Hospital. Dr. Abercrombie* mentions a case in which the inner table alone of the calvaria was thus extensively destroyed. In Norris's case† the disease attacked both tables of the whole of the calvaria, and extended even as far as the foramen magnum. The skull is now in the Museum of the Royal College of Surgeons.‡ Mr. Drummond's case§ affords another example of extensive destruction of the vault of the skull, originating in a blow on the head. But of cases of this kind, Saviard's || is the most extraordinary. In this case, two years after a blow on the head, the whole skull-cap came bodily away.

The treatment of such cases differs in no wise from that of caries and necrosis of the skull arising from other causes. Matter pent up under the scalp must be let out, and the loose pieces of bone removed; and occasionally, but very rarely, the application of the trephine may become necessary. But in this

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* *Diseases of the Brain*, 2nd edit. p. 189.

† *Trans. of the Med. Soc. of London*, vol. i. p. 168.

‡ *Pathol. Cat.*, 1847, vol. ii. p. 115. It is entered as a specimen of tuberculated syphilitic disease; but this is an error.

§ *Med.-Chir. Trans.* vol. xxxiv. p. 103.

|| *Rec. d'Obs. Chir.*, 1762, p. 386.

we cannot be too cautious, notwithstanding the brilliant results obtained in former times by the extensive application of this instrument.

In the above cases, the mischief in the bone was chronic; but a blow on the head, with or without a scalp wound denuding the bone, may be followed by inflammation of an acute character, the starting-point of which is in the diploë, where the blow is followed by an extravasation of blood, or a breaking-down of the cancellous tissue; the compact tables suffering but little from the injury.

Inflammation of the diploë, in connexion with such a contusion, is fraught with danger. The inflammation may at any moment spread to the internal table of the bone, and from thence to the membranes of the brain; and, involving some of the veins of the diploë, it may also lead to purulent infection, and secondary deposits in various parts of the body.

The patient having recovered from the immediate effects of the injury, may for a time appear to be in perfect health; and thus matters generally go on for a fortnight or three weeks, when a change, slight at first, takes place. When there is a wound, it loses its healthy aspect, and this is accompanied by feverishness and pain in the head; then follows a spontaneous secession of the periosteum; and the bone, if denuded, becomes dry and discoloured. Such are the first indications of mischief; and now, should the inflammation spread from the internal table of the bone to the dura mater, this membrane secedes from the affected bone, and its outer surface is covered with lymph or pus. Thus far the mischief is circumscribed; but when the inflammation reaches the parietal arachnoid, it spreads more or less over the free surface of this membrane, and soon involves the viscera layer of the arachnoid, the pia mater, and the corresponding surface of the brain. Meanwhile the symptoms become more and more marked—increased feverishness, repeated rigors, intense pain in the head, sickness, drowsiness, occasional wandering, coma, and sometimes paralysis.

In all this, it is held that the affection of the bone is the essential element; and such no doubt is the rule. It was, however, taught by Pott,* that the affection of the bone was only secondary to that of its membranes.

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* *Inj. of the Head*, 1768, p. 39.

In the treatment of these cases, the first question is, whether the inflammation likely to arise from a contusion of the skull-bone can be prevented. Free blood-letting at the onset of the symptoms would, it was at one time thought, prevent further mischief; and by Pott,[*] especially, great success was attributed to this plan of treatment. But, as I shall hereafter explain, these successful cases were, I believe, instances of inflammation beginning, not in the dura mater, but in the visceral layers of the membranes of the brain, and dependent upon what is commonly called concussion. It is no doubt right, as soon as inflammatory symptoms make their appearance after a blow on the head, to have recourse at once to antiphlogistic remedies; but the prospect of the benefit likely to be derived from our treatment must depend upon the cause of the inflammation. In inflammation dependent upon concussion of the brain, antiphlogistic remedies will, in the great majority of cases, be of very great use; but in inflammation beginning in the diploë and spreading to the dura mater, they will be of little or no avail; and hence the reason why we so commonly find these cases running their course, notwithstanding blood-letting, mercury, &c.

The increase of the symptoms leads to the question of trephining in such cases.

Trephining for matter between the bone and the dura mater appears, in Pott's hands, to have been a most successful operation. Blow on the head—subsequent secession of the pericranium—pain in the head—fever—rigors—application of the trephine—evacuation of matter—cured. Such is the history of the majority—five out of eight—of the cases in which Pott applied the trephine.[†] But no such success has attended the practice of other surgeons. On the one hand, the dura mater has been found, over and over again, perfectly sound in cases where the trephine has been applied for precisely similar symptoms; and, on the other hand, although matter may have been found between the bone and the dura mater, the patient has nevertheless died. I have repeatedly seen the trephine applied under such circumstances, and matter evacuated, but without any permanent benefit. Indeed, the successful issue of a case of trephining for matter between the bone and the dura mater is, I believe, all but unknown to surgeons of our own time.

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[*] *Inj. of the Head*, 1768, p. 55.

[†] Op. cit., pp. 63-107.

Pott was successful because the inflammation in the majority of his cases happened to be strictly limited to the outer surface of the dura mater; and this Pott thought was frequently the case: but further experience has proved that this strict limitation of the inflammation is quite exceptional. In every case of contused bone in which I have found inflammation on the outer surface of the dura mater, I have also found inflammation on the free surface of the arachnoid.

With this all-but constant diffuse suppuration of the arachnoid which accompanies inflammation of the dura mater in connection with contused bone, there is, then, but very little hope of doing any good by trephining; but as the operation is the only chance left, we must not lay the trephine aside altogether, as some surgeons have done in these cases.

In order, however, that we may avoid the risk of applying the trephine in cases where the dura mater is healthy, we must be especially careful to operate in those cases only where, in addition to fever and rigors, and to the local signs about the bone, there are also well-marked brain-symptoms—coma, and, better still, hemiplegia. With such a train of symptoms, lymph or pus has invariably been found between the bone and the dura mater in all the cases in which I have seen the skull perforated.

Now and then, but very rarely, the matter in the cavity of the arachnoid, instead of being diffused, is limited by lymph glueing together the two layers of the serous membrane; and thus is formed a perfectly circumscribed abscess. In such cases, after the skull has been perforated, the dura mater bulges into the trephine-hole; and it is tense, and without any pulsation. Here there is no doubt as to what is to be done. The dura mater must be cut into, in order that the matter be evacuated. It was by thus incising the dura mater that Guthrie* saved the life of one of his patients. In Roux's case,† after the removal of the bone by the trephine, a large hole was found in the dura mater; this gave free vent to a collection of matter circumscribed within the cavity of the arachnoid, and the patient got well. And Mr. Dumville's recent case affords another striking instance of circumscribed suppuration within the cavity of the arachnoid, and similar in some points to M. Roux's. The girl, Mary Driskell, was admitted into the Manchester Royal Infirmary for a scalp wound and denudation of the frontal bone. The symptoms first made their appearance three weeks after the accident, and led to the supposition that matter had formed between the bone and the dura mater. The trephine was applied: no matter was found on the dura mater, which, however, was whiter and thicker than usual, except at one point of the margin of the trephine-hole, where there was a red spot; this proved to be a small hole in the dura mater, into which the flat end of a probe was passed, whereupon a quantity of most offensive matter spirted out. The symptoms were relieved, and the patient ultimately got well.*

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* *Inj. of the Head,* p. 127. † *Arch. génér. de Méd.* 1830, vol. xxiv. p. 268.

But of all the complications incident to the slighter forms of injury of the head, none is so fatal as purulent infection, which may arise out of a simple wound of the scalp, or, as is much more frequently the case, be connected with contusion of the skull, followed by inflammation and suppuration of the diploë, in which some of the large and numerous venous canals of the bone have become implicated.

In purulent infection arising out of either of these causes, the brain and its membranes may remain perfectly healthy. With contusion of bone, however, it much more commonly happens that purulent infection is associated with intra-cranial suppuration.

The frequent association of purulent infection with slight injuries of the head must be kept constantly in view; for its symptoms sometimes resemble very closely those of intra-cranial suppuration; so much so that, unless on our guard, we may be misled, and especially in the early stages, when there are as yet no signs of mischief in other parts of the body. And the diagnosis will be still more difficult, if not altogether impossible, in those cases where there is matter between the bone and the dura mater, as well as purulent infection.

For a long time the liver was thought to be the spot in which secondary abscesses occurred in connection with an injury of the head; but further experience has proved that matter may, in such cases, form in any and in every part of the body, and that the lungs are, of all parts, the most frequently thus affected. Out of eighteen cases, in all of which the purulent infection occurred either after a wound of the scalp or a contusion of the bone, I found the lungs studded with secondary abscesses in thirteen cases, and the liver in three; and out of these three the liver alone was affected in one case only, and in the other two the lungs were affected as well as the liver. In purulent infection, the serous membranes are also frequently the seat of secondary inflammations; and here we shall also find that the serous membranes of the chest are much more frequently affected than that of the belly. Thus, out of these eighteen cases, the pleura was extensively inflamed in no less than in twelve cases, and the peritonæum in one case only. In some of these cases the inflammation was confined to the serous membrane; but in most of them the pleura and the lung were both affected. In the limbs, the joints are not unfrequently filled with matter, and large collections of pus occur at different points in the cellular tissue. Even the skin, as is now well known,* may become affected in purulent infection. Now and then, but very rarely, the skin is studded with small deposits of matter, looking exactly like the pustules in a bad case of small-pox. Of this I have seen only two or three instances. In other cases, the skin is covered with sundry patches of a purple hue, resembling the circumscribed patches of congestion commonly seen about the lung in an early stage of the disease; and in other cases, again, a large portion of the skin is suddenly stricken with mortification, which proceeds very rapidly. Of this I have seen several instances.

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* *Brit. Med. Journ.* 1858, vol. ii. p. 743.

A careful examination of the venous system of the head shows, in some cases, the veins of the scalp filled with pus: in other cases, pus is found in large quantities in the veins of the diploë; so much so that, in trephining for matter between the bone and the dura mater, I have several times seen pus streaming out of the large venous canals of the diploë; and within the skull, the veins on the surface of the hemispheres are sometimes loaded with pus, and so too, and much more commonly, is the superior longitudinal sinus.

In purulent infection, surgery can do nothing unless the pus happens to be altogether effused into parts which are accessible, such as the joints, or the cellular tissue. Of late years, however, M. Chassaignac has proposed that we should once more resort to the trephine as a preventive; that we should cut out the contused piece of bone in which suppuration is likely to take place, and thus remove the starting point of the disease. But the objections to this proposition are so obvious, that few surgeons will, I think, venture to put it into practice.

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* Henry Lee, *Infl. of the Veins*, &c., 1850, p. 53.

And medically, our only hope is in keeping up the general strength by all possible means, bearing in mind that cases do now and then occur in which recovery takes place, notwithstanding clearly-marked symptoms of purulent infection—cases in which inflammation of the lung has existed, and in which large collections of matter have burst, and been brought up.

In dealing with purulent infection—in dealing, too, with erysipelatous and diffuse cellular inflammation of the scalp—we must also bear in mind, that disease of the kidneys may possibly be at the bottom of the evil. Patients affected with Bright's disease are especially liable to extensive inflammations of the cellular tissue, just as well as of the serous membranes. And in this condition of the kidneys one not unfrequently sees diffuse cellular inflammation beginning around a slight wound of the scalp, and rapidly spreading over the head and face, and down the neck into the mediastina. In such cases, too, one or more of the serous membranes may also be filled with sero-purulent fluid.

Extravasations of Blood.

Blood may be extravasated in the soft parts external to the bone; in the bone itself; between the bone and the dura mater; within the arachnoid; in the pia mater; in the structure of the brain, or in its ventricles.

In the parts external to the bones. The extravasation may take place between the skin and the occipito-frontalis muscle, in the loose cellular tissue under this muscle, or beneath the periosteum. In either of these situations the extravasation may be infiltrated into the tissues, or enclosed in a cavity more or less well circumscribed.

Infiltrated. In the very dense cellular tissue between the skin and the occipito-frontalis muscle, the blood presents itself as a hard unyielding lump; but beneath the muscle it spreads through the meshes of the loose cellular tissue, and gives rise to a crackling sensation.

Enclosed in a cavity. The extravasation may form either a prominent tumour, with a soft centre and a hard base, or a diffused swelling, with boundaries gradually lost in the surrounding tissues. Diffused swellings of this kind occur as well under the pericranium as in the loose cellular tissue above this membrane; and in either case the collection of blood may be such as to cover over the whole surface of the calvaria.

The fluid in these collections varies very much at different periods: it may be blood, arterial or venous, in a more or less fluid state; or a thick viscid fluid, of a dark, bistre colour; or bloody serum with clots, or serum alone. And the cavity containing the fluid, formed at first by the surrounding tissues only, is subsequently lined by a perfectly-formed membrane possessing all the attributes of an original serous tissue, and to this is sometimes added a thick deposit of fibrine disposed in layers such as are found in an aneurism.

The diagnosis of extravasations of blood external to the bone is, for the most part, easy; but the extravasation with a hard ridge round its base and a soft centre may lead to some difficulty. It has been mistaken for a fracture with depression, and that by some of the most practical surgeons; and all the more readily may such an error occur when the swelling, in connection with a lacerated artery, pulsates.

In the treatment of these external extravasations of blood there is generally but little to be done; in due course of time the blood is absorbed. But it occasionally happens that the collection persists, and even increases in size, and under such circumstances it may be necessary to evacuate the fluid. This must be done by a small puncture, after which compression is to be established over the whole surface of the swelling. In large collections, such puncturings may have to be repeated several times; and in an encysted collection of large size, should the fluid be of a serous character, and recur again and again, an iodine-injection might be thrown into the pouch. And when suppuration occurs, the pouch must here, as everywhere else, be at once freely laid open.

Extravasations of blood *in the diploë*, and the consequences to which they may give rise, have already been dwelt upon in the previous section.

Extravasations of blood *between the bone and the dura mater* may proceed from the small vessels passing from the one to the other, or from some of the large vessels lodged in the grooves on the inner surface of the skull. The former extravasations, generally speaking, are of small size; but the latter may be very extensive, widely separating the membrane from the bone over the greater part of one side of the skull. Of the large extravasations, the most frequent by far is that from the middle meningeal artery. Out of thirty-one cases of fracture of the skull, accompanied by extensive extravasation, the blood had proceeded from the middle meningeal artery or its branches in twenty-seven cases. Occasionally the extravasation proceeds from one of the large venous sinuses, and of these the lateral is more commonly lacerated than any other sinus. One of the most extensive extravasations of blood between the bone and the dura mater which I have seen, proceeded from a rupture of the lateral sinus, just as it turns under the petrous portion of the temperal bone.

The spot usually referred to in extravasation of blood from the middle meningeal artery is the anterior-inferior angle of the parietal bone; but extensive extravasations may occur from this vessel or some of its branches over pretty nearly the whole of the lateral surface of the skull. In fractures involving the middle fossa, the most common of all the fractures of the base of the skull, this vessel may be torn across in any part of its course between the foramen spinosum and the anterior-inferior angle of the parietal. And in the middle fossa of the skull, it frequently happens that the middle meningeal artery divides itself into two large branches of equal size, one proceeding to the anterior-inferior angle of the parietal, and the other passing much more posteriorly, which send large ramifications over the whole of the parietal and the corresponding parts of the frontal and occipital. A fracture running across any of these large branches may give rise to an extensive extravasation of blood.

A collection of blood between the bone and the dura mater differs widely from extravasations of blood in other parts of the cranial region. It always presents itself in the shape of a hard granular mass, breaking down with great difficulty, even under heavy pressure, and adhering most firmly to the parts between which it is lying; separating, more or less widely, the dura mater from the bone; and pressing upon the brain itself, sometimes to such an extent as to produce a large cup-like cavity on its surface.

The changes likely to take place in such an extravasation, should the patient live, are very few. It has been doubted whether blood between the bone and the dura mater could be absorbed; but in one instance, where the patient lived for a few weeks after the accident, I found thus situated a small hard clot, which had already lost the greater part of its colouring matter, and was undergoing the process of absorption. As for these collections becoming encysted, of this I know no well-authenticated case; neither have I ever seen, even after several days, anything approaching to the formation of a cyst.

The symptoms dependent upon an extravasation of blood between the bone and the dura mater vary very much. In small extravasations the symptoms may be but slightly marked; and in a slow outpouring of blood, the brain may have time to accommodate itself to the pressure. In well-marked compression, however, the patient is generally perfectly insensible: the breathing is slow and laboured, oftentimes stertorous, and sometimes accompanied by a peculiar whiff at the corner of the mouth; the pulse too is slow and laboured; the pupils may be either contracted or dilated, and the eye fixed and insensible to light; there is paralysis, more or less complete, of one side, with retention of urine and involuntary discharge of fæces.

It unfortunately happens, however, that the symptoms of compression bear at times a very close resemblance to the symptoms of concussion and of contusion of the brain, so much so in some cases that it may become a difficult matter to decide as to the exact nature of the injury. But however alike the symptoms of compression and of concussion may at times be, there is this marked difference between the two states—in concussion, the effects are instantaneous; and in compression from extravasated blood, some little, it may be a very short, time elapses before the symptoms manifest themselves; in the former, also, the symptoms gradually pass off, but in the latter they become more and more marked.

In the year 1839, a man was struck with a spade just over the anterior-inferior angle of the right parietal; and when he came to St. George's Hospital a few minutes afterwards, a compound fracture, with depression of a small piece of the skull, was detected, but there were no cerebral symptoms whatsoever. Shortly afterwards, however, the patient became heavy and stupid; and coma was gradually supervening, when Mr. Keate arrived, and at once proceeded to remove the depressed bone, whereupon a jet of blood spirted out from a large branch of the middle meningeal artery, and all the symptoms of compression were immediately relieved.

In this case there was no doubt as to the symptoms being wholly dependent upon the extravasation of blood which was going on under the bone; there was no injury of the brain itself, and the interval between the blow and the symptoms was clearly marked. But had concussion of the brain existed, the outpouring of blood might have taken place when the patient was insensible, and then we should have lost our most valuable means of diagnosis, the 'interval of time.' Again, in civil hospitals, nearly all large extravasations of blood between the bone and the dura mater coexist with contusion and laceration of the brain-substance. The post-mortem records of St. George's Hospital show that within the last few years there have been twenty-five cases of large extravasations of blood between the bone and the dura mater, in all of which the brain was more or less extensively lacerated.

Injuries of such a compound nature easily explain the difficulties as to diagnosis, and the reason why the trephine is so seldom applied nowadays for extravasated blood; and why also, when resorted to, the operation so seldom succeeds.

But cases now and then occur in which there is no doubt as to the propriety of applying the trephine, and in which its application is followed by the most signal success. Of this Mr. Keate's case above mentioned affords a striking illustration; and in the year 1842 there was another case of the same kind, at St. George's Hospital, under the care of Mr. Tatum, and in which the operation was equally successful.

In other cases, the history of an extravasation of blood may be perfectly clear, but there may be no local sign as to the seat of the injury, and perhaps even nothing to guide us as to which part of the head was struck. Under such circumstances, operative interference is out of the question, unless paralysis be present.

But should paralysis exist on one side, we may infer that the extravasation of blood is, at any rate, on the opposite side; and then an incision over the lower part of the corresponding parietal is warranted; for a fissure of the skull may thus be laid bare, the trephine applied, and the patient saved.

In the cavity of the arachnoid, traumatic extravasations of blood occur much more frequently than in any other part within the skull. Such extravasations are, indeed, very common, and much more so than is usually supposed. Blood is found in the cavity of the arachnoid in the great majority of severe injuries of the head; and I have frequently found it also in cases where the injury has been a trifling one, and that without any apparent lesion either about the brain or its membranes.

In the majority of instances the blood corresponds to the cerebrum, rarely to the cerebellum, and still more rarely to the medulla oblongata.

Blood extravasated within the cavity of the arachnoid undergoes, in the course of time, various changes, which it is important to notice.

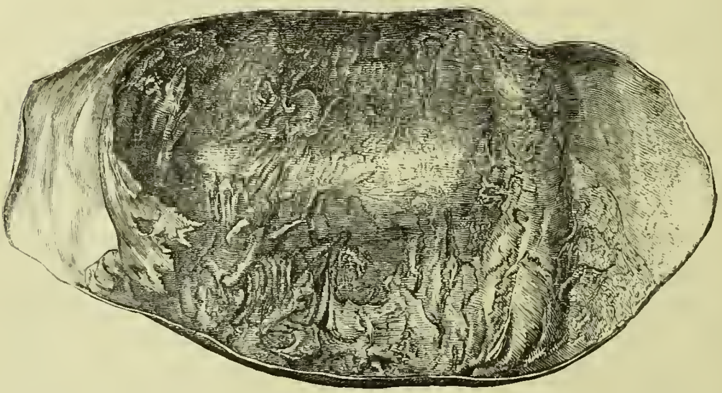
In the earlier stages, the blood, when coagulated, is flattened and moulded, membrane-like, upon the parts between which it lies. In this shape I have frequently found large quantities of blood spread over and capping both hemispheres of the brain. After a time the colouring-matter of the blood disappears, more or less; and thus are formed the membranes, of different hues, which are found within the arachnoid after an injury of the head. In slight extravasations, all that may be found after a few days is a mere film, so delicate and so slightly tinged as easily to escape notice.

In the great majority of cases, the false membrane is firmly attached to the parietal arachnoid (Fig. 41); its free surface, perfectly smooth and polished, presents the appearance of a serous tissue; and its structure is throughout plentifully supplied with blood-vessels, which may be readily seen with the naked eye. I have met with all these characters, well marked, three-and-twenty days after an injury.

These blood-membranes, at first soft and pulpy, may subsequently become leathery, fibrous, or even cartilaginous; and, under such circumstances, they have been referred to and described as diseases of a very different character, and especially chronic inflammation.

Extravasations of blood into the cavity of the arachnoid not unfrequently give rise to appearances of a most deceptive character. The blood, glued to the parietal arachnoid, and covered over by a thin, polished, serous-like membrane, looks exactly as if the extravasation had taken place between the dura mater and its arachnoid, and widely separated these membranes from each other. But the true nature of these cases has of late years, and especially by the French pathologists, been clearly made out.*

FIG. 41.



Layer of coagulated blood attached to the parietal arachnoid, from which it has been separated at the upper part.

Instead of forming simple layers of membrane, the blood, if the extravasation is a large one, may in the course of time give rise to the formation of a large perfectly-closed bag, in which are contained the more fluid parts (Figs. 42, 43). Such blood-cysts may contract more or less extensive adhesions with both layers of the arachnoid; but they are, for the most part, glued to the parietal arachnoid only; and, in some rare cases, they have been found lying perfectly loose in the cavity of the arachnoid. In M. Leriche's case,† the blood-cyst lying loose in the cavity of the arachnoid was an inch and a half in width; and it covered over the greater part of the upper surface of the left hemisphere, where it had imbedded itself. In Dr. Quain's case,‡ the cyst fell out of the cavity of the arachnoid when the dura mater was incised; and measuring in length seven inches and a half, and in width one inch and a half at its broadest part, this cyst had formed a corresponding depression on the upper surface of the cerebral hemisphere. The preparation is now in the Museum of St. George's Hospital.

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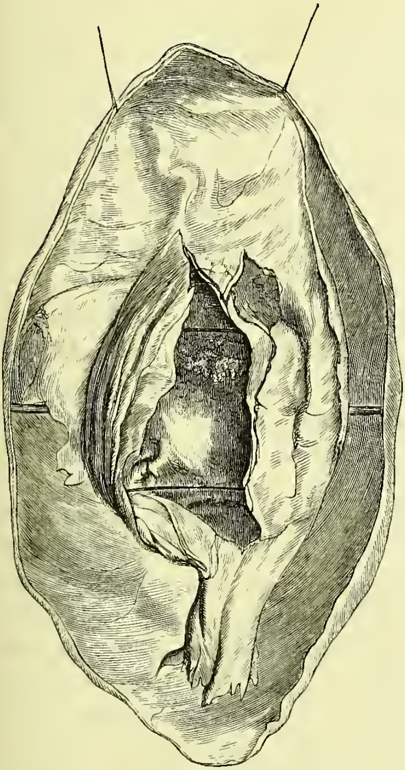
* Prescott Hewett *On the Ext. of Blood into the Cavity of the Arach., Med.-Chir. Trans.* vol. xxviii. p. 45.

† *Bull. de la Soc. Anat. de Paris,* t. x. p. 55.

‡ *Trans. Path. Soc. Lond.* vol. vi. p. 8.

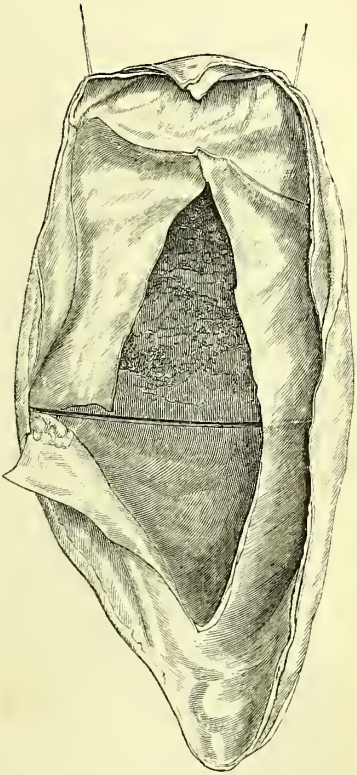
When glued, as they commonly are, to the parietal arachnoid, these blood-cysts are thoroughly supplied with blood-vessels; and thus organised, these cysts possess all the physiological characters of an original serous membrane. They secrete; they absorb; they have been found filled with clots of fibrine and blood-tinged serum; sometimes they contain serum alone, of various colours; and oftentimes in the cavity of the same cyst are found clots of blood of various colours, some recently effused, and others of long standing.

Fig. 42.



Large blood-cyst, attached to the parietal arachnoid; the cyst laid open to show its cavity.

Fig. 43.



Another large blood-cyst, also laid open, and dissected off from the parietal arachnoid in the greater part of its extent.

When the cyst is a large one, it presses upon the corresponding part of the brain, the convolutions of which become flattened, or slightly depressed, presenting a cup-like surface, and the corresponding ventricle is contracted. The pressure of the cyst, in long-standing cases, diminishes the thickness of the bones; and, in some cases, when formed in early childhood, such cysts have been known to lead to bulging of the bones outwards.*

There are no symptoms which will enable us clearly to diagnose an extravasation of blood into the cavity of the arachnoid.

If slight, such an extravasation may be followed by no symptom whatsoever; and, even in larger quantities, when spread out in membranous layers, the blood may produce no very decided symptoms of compression; and most frequently, connected as these extravasations are, in the great majority of cases, with some severe injury of the cerebral substance itself, the symptoms of one lesion are mixed up with, or totally masked by, those of a very different nature.

But should symptoms of compression follow a traumatic extravasation of blood in the cavity of the arachnoid, they will be the same as those of a collection of blood upon the outer surface of the dura mater; and a surgeon may thus be led to apply the trephine under the supposition that the blood is in this situation.

And now, supposing the trephine to have been thus applied, and no blood found between the bone and the dura mater, still the blood in the arachnoid may chance to lie immediately under the spot, and the dura mater, of a blue colour, may bulge into the trephine-hole. Under such circumstances, blood in the cavity of the arachnoid has several times been let out, and the patient saved. When, however, there are no indications of the blood in the arachnoid being under the trephine-hole, there is nothing to justify the surgeon in proceeding further.

Traumatic extravasations of blood in the cavity of the arachnoid sometimes give rise to a permanent affection of the brain.

In Dr. Quain's case above cited, in which a large blood-cyst was found loose in the cavity of the arachnoid, the injury was followed by constant pain in the head, great irritability of temper, despondency, and subsequently by fits, which recurred from time to time. In Mr. Fisher's case, published by Mr.

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* *Lancet*, 1846, vol. i. p. 416.

Hancock,* the patient, a young gentleman, became insane after a violent blow on the head from a cricket bat or ball, and in this state he remained, with occasional lucid intervals, for fifteen years, and all that was found after death was an enormous encysted collection of blood in the cavity of the arachnoid. And in Foville's † and Blandin's ‡ cases, both of old soldiers in whom severe injuries of the head were followed by insanity, large collections of blood were years afterwards found encysted in the cavity of the arachnoid.

Traumatic extravasations of blood *in the pia mater* differ in many respects from those in the cavity of the arachnoid. They certainly occur less frequently, and they very rarely exist without some laceration of the brain-substance. Beneath the arachnoid, an extravasation of blood spreads into parts far away from the original seat of the injury, and the whole cerebellum and spinal marrow may thus be covered with blood proceeding from a laceration of the cerebrum only. In the pia mater, too, an extravasation of blood never, as far as I am aware, gives rise to encysted collections such as those which have been described in the cavity of the arachnoid.

It was at one time thought that these widespread extravasations of blood in the pia mater were apt to produce more urgent symptoms than those collections of blood in one mass which give rise to a less general pressure; but further experience has not confirmed this opinion, and it is now admitted that there are no symptoms by which an extravasation of blood in the pia mater can be recognised. Neither is there any possibility of these extravasations being let out, even supposing the dura mater to have been laid open. The constant infiltration of the blood in the pia mater precludes any such fortunate result.

Injuries of the head sometimes give rise to large extravasations of blood *in the structure of the brain*, and occasionally, too, the ventricles are found filled with blood after injuries of this kind. But in dealing with such cases great caution is necessary in order to avoid, if possible, mixing up cases of apoplexy with those of traumatic effusions. An accident coexisting with an extravasation of blood in the cerebral substance does not necessarily imply cause and effect; the previous condition of the brain or the outpouring of blood from diseased vessels, may, in fact, have been the cause of the accident. There is no doubt that many a case reported as one of traumatic effusion of blood in the brain was simply a case of apoplexy.

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* *Lancet*, 1846, vol. i. p. 416.

† *Dict. de Méd. et de Chir. Prat.* t. xi. p. 407.

‡ *Anat. des Régions*, 2^{me} éd. 1834, p. 36.

Minute extravasations of blood in the brain will find their appropriate place in the subject of CONTUSION OF THE BRAIN.

Collections of blood in the brain, or in its ventricles, the result of an accident, may run through the numerous and well-known changes of a simple apoplectic effusion. But such changes seldom, however, take place in traumatic extravasations, which are generally rapidly fatal, being, as they are for the most part, associated with other severe lesions of the cranial contents.

The symptoms of a traumatic extravasation of blood into the brain are the same as those of an apoplectic effusion. And the treatment, too, must be precisely similar. It, as well as all other treatment of intra-cranial extravasations, not admitting of operative interference, must be purely medical.

FRACTURES OF THE SKULL.

These fractures may, for practical purposes, be conveniently divided into fractures of the vault, and fractures of the base, of the skull.

Fractures of the vault. In the vault, most of the fractures are direct; the bone gives way at the spot which was struck, and the result may be simply a fissure, or the bone may be broken into fragments.

The fissure is most frequently not limited to the seat of the injury; sometimes it spreads through various bones, and oftentimes reaches from the vault into the base.

The comminuted fracture is much less apt to spread; produced by a more or less concentrated blow, such a fracture is for the most part limited to the seat of the injury.

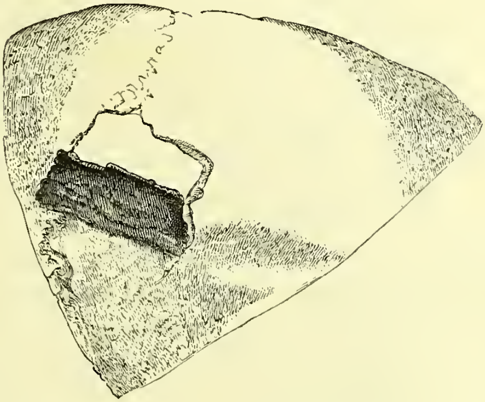
The comminuted fracture and the fissure may coexist, and this especially in cases of a heavy blow acting on a large surface.

Fractures of the vault may be limited to the outer or to the inner surface of the skull; but such fractures by far most commonly extend through the whole thickness of the bone.

And the broken bone may either retain its proper level, or be driven outwards or inwards.

The displacement outwards very rarely happens; there are, however, two specimens of it in the Museum of St. George's Hospital. In both specimens, a piece involving the whole thickness of the bone, having been detached on three sides, is bent outwards, and thus raised two or three lines above the level of the skull: the fragment is, however, immovable, as it is still connected at one side to the surrounding bone, the external table of which is, at this part, only partially fractured; the appearances may, in fact, be said to resemble the lid of a box partially open. In one instance the injury was produced by a chisel falling from a great height on to the head; and in the other, the patient, in a fall from a great height, struck his head upon some iron railings, one of which penetrated the skull.

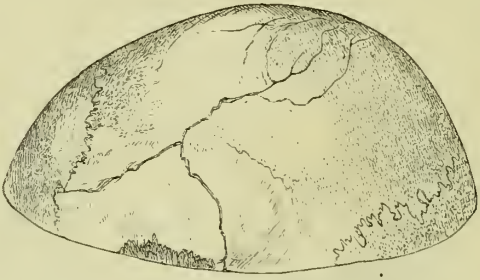
FIG. 44.



Fracture of the skull, with displacement outwards.
From St. George's Hospital Museum.

The displacement inwards is of very common occurrence. The external table alone may be driven down; and this may happen in any part of the vault, but especially in the region of the frontal sinuses, where the depression may be very extensive, without any injury of the inner table. The inner table alone may be broken and depressed, without a trace of injury about the outer parts of the bone. Cases such as these are, it is true, very rarely met with; but extensive splintering and depression of the inner table not unfrequently exist, with some slight injury of the outer table. In the Museum of St. George's Hospital there is a skull-cap (Figs. 45, 46) with a comminuted fracture of the inner table with extensive depression, and in the outer table corresponding to this there are merely some slight cracks. And in another preparation in the Museum of St. George's Hospital, with splintering and depression of the inner plate alone, there is a simple clean cut, of an inch long, through the outer layers of the bone: the boy had fallen out of a cart, and no doubt the bone was cut by some sharp piece of stone lying on the road. In his remarks upon this important subject, it was to sabre-cuts that Mr. Guthrie* referred especially; but such

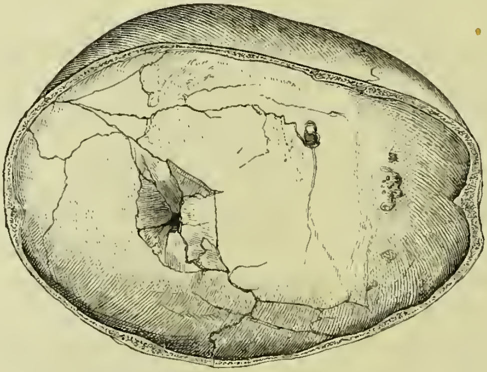
Fig. 45.



Fracture of skull, with depression of inner table.

Outer surface.

Fig. 46.



Fracture of skull, with depression of inner table.

Inner surface.

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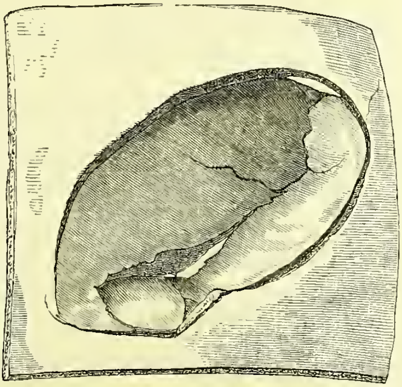
* *Inj. of Head*, p. 86.

appearances about fractures of the skull are by no means uncommon in civil hospitals. A smart blow inflicted on the skull by a more or less pointed instrument—a nail, the corner of a brick, a piece of flint, the angle of a slate—may produce such a fracture. M. Denonvilliers * presented to the Société de Chirurgie de Paris a specimen of this kind, in which the injury had been produced by a slate falling on the head. A case is also described by Mr. Benjamin Phillipps,† in which a large fragment about two inches and a half long was found completely detached from the inner table, and sticking in the dura mater; in the outer table was a clean cut made by a flat-iron or shovel. In Samuel Cooper's ‡ case the injury was caused by a nail projecting from a door which had fallen upon the patient.

Fractures with depression involving the whole thickness of bone present some varieties deserving of notice. There may be, as in a specimen in the Museum of St. George's Hospital, a single line of fracture extending some distance, with an extensive over-riding of one side of the fracture. A very common form of fracture with depression is that in which an oval piece of bone is not only driven down, but split longitudinally in two fragments which slant towards each other, the depression being much greater at the centre than at the circumference. With such appearances on the outer surface, the fracture of the inner

Fig. 47.



Depressed fracture of skull, in an oval-shaped piece, driven down and split.

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* *Compend. de Chir. Prat.* t. ii. p. 578.

† *Med. Gaz.* vol. xxxiii. 1844, p. 129.

‡ Erichsen, *Surgery*, 2d ed. p. 280.

plate is much more extensive and much more irregular. A specimen in the Museum of St. George's Hospital (Fig. 47) affords a strongly marked instance of this form of fracture, of which I have seen several cases. Such a fracture is commonly produced by some heavy body with a sharp margin applied with great force—a quoit or a horse-shoe. But perhaps the most ordinary form of fracture with depression is that in which several fragments, more or less of a triangular shape, have their points extensively driven down and firmly wedged into each other, whilst their bases still remained on a level with the surrounding bone. Taken as a whole, the broken portion is here, too, almost always of an oval shape, and cracks and fissures involving only the outer table are frequently found disposed around the depresed piece. And here too, whatever be the extent of the injury in the outer part, that on the inner side is much more extensive still. And so it is in all ordinary cases of fracture with depression.

The more extensive splintering and depression of the inner table of the skull is usually attributed to its greater density and consequent brittleness; but there is no doubt that the direction in which the force acts tends in some measure to produce these effects. Of this Mr. Erichsen* mentions a well-marked example. A man fired a pistol into his mouth, and the ball in passing out of the skull first struck the inner and then the outer plate of the vault. The result was, that the outer plate was much more extensively splintered than the inner one.

As to traumatic depression of the skull without a fracture, of this we have no well-authenticated specimen in the adult. And until such a preparation be brought forward, the existence of this form of injury in the adult ought not to be admitted. In young children with very pliant bones, it is just possible that such an accident might occur; but even here, in a well-marked depression, some of the bony fibres must have given way.

A wound of the integument leading down to the bone may accompany every variety of fracture of the vault. And in these compound fractures, the injury of the bone is very much more frequently strictly limited to the seat of the blow than it is in cases of simple fracture. Out of twenty cases of compound fracture of the vault, the injury of the bones was thus strictly limited to the seat of the blow in eight cases; in six of which the injury was produced by heavy blows, falls, or blunt instruments, and in two by sharp instruments. But out of fifty-six cases of simple fracture this strict limitation existed only in one single instance, and in this case the patient, having fallen off his coach-box, had struck his head against the ground.

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* Op. cit. p. 278.

Are there any signs by which we can in all cases recognise the existence of a fracture of the vault? No. Fissures involving the whole thickness of the vault of the skull constantly exist without ever having been suspected during life; and even an extensive and a comminuted fracture with great depression of the fragments may, and often does, escape notice, when the broken bone lies hidden under the temporal muscle or under a large extravasation of blood. And, on the other hand, an extravasation of blood may be mistaken for a fracture with depression, and so too may an abnormal depression of the skull. Such a depression may depend upon a congenital malformation, or be produced by absorption of the diploë and thinning of the tables, as sometimes occurs in the skull, especially in elderly persons.

Accompanied, however, by a wound leading down to the bone, fractures of the vault are, in general, easily detected; but even here appearances are sometimes deceptive, and sutures and vascular grooves have been mistaken for fissures. In some of these cases the error, no doubt, arose from carelessness; but an abnormal disposition of a suture may mislead the most attentive. And unless careful, even in compound fractures with depression, we may be led into error as to the exact condition of the inner plate of the bone.

There is, however, one sign indicative of fracture of the skull about which one would have thought that no mistake could possibly have occurred. But Maréchal* mentions a case in which the inspissated secretion of the frontal sinuses was mistaken for brain-substance, thought to be oozing out of a fracture in this region.

There is also on record † a singular instance of the appearances which may lead to an error in diagnosis as to a compound fracture of the skull. A woman was admitted into the Hôtel-

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* *Mém. de l'Acad. de Chir.* t. I. p. 247.

† Denonvilliers, *Thèse de l'App. du Trépan,* p. 16.

Dieu with a wound in the temporal region, accompanied by profuse bleeding. A fragment of bone, several lines in length, was found deep in the wound and quite loose ; this was removed, and the finger then passed through an opening, the circumference of which was unyielding. The case was at once thought to be one of compound fracture, with separation of some fragments. But it was soon remarked by a bystander, that the fragment of bone which had been removed was dry, and quite white, as if it had been macerated. This led to a more careful examination of the wound, and it was discovered that the supposed hole in the skull was nothing but a laceration of the temporal fascia, and the fragment, the innocent cause of the error, turned out to be simply a piece of bone which, lying on the ground, had been driven into the temple when the patient fell.

In the treatment of fractures of the vault of the skull are involved some of the nicest and most litigated points in the practice of surgery.

And first, as to lineary fracture or fissure. Unaccompanied by brain-symptoms, such fractures, even when compound, are not to be interfered with ; the wound must be treated according to circumstances, and the case carefully watched for some time. Now and then a fissure of the skull, simple or compound, is followed by suppuration between the bone and the dura mater, the symptoms and treatment of which have already been noticed in the subject of 'contusion of bone.'

A few years back, and it was held that intra-cranial inflammation would, in all probability, follow a fissure of the skull ; and hence the precept of Pott,* 'that perforation is absolutely necessary in seven cases out of ten of simple undepressed fracture of the skull.' But of inflammation following a fissure, one case only was met with in the wards of St. George's Hospital during a period of ten years, and in this case there was a wound leading down to the bone. The case, as in 'contusion of the bone,' went on well for upwards of a fortnight ; and then, on the seventeenth day, came the symptoms of intra-cranial mischief, and death followed, notwithstanding the application of the trephine.

The principle of non-interference also holds good in a comminuted fracture, even with depression of the fragments, provided there be no wound of the scalp and no symptoms. It is now an established rule in our metropolitan hospitals that simple fractures of the skull with depression and without symptoms are to be left alone. The depression may be so marked as to be easily detected; and yet, so long as there are no symptoms, all operative interference, of whatsoever kind, is carefully to be avoided.

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* *Inj. of the Head,* p. 130.

In such a case the recovery may be as rapid and as uninterrupted as if there had been no depression of the bone. But it must not be forgotten that such a depression may at any subsequent period lead to internal mischief of a serious nature; and the patient ought to be put upon his guard as to the risks which he for the future may be subjected to.

But supposing there be a wound leading down to the bone in a depressed fracture without symptoms, what is to be done? Are we to operate at once, or not? The rule is, that we are to operate, and at once. Compound fractures of the skull with depression most frequently lead, as demonstrated by Sir A. Cooper and Sir B. Brodie,* to intra-cranial suppuration; and hence the rule laid down by these celebrated surgeons, that we are to operate to prevent the impending mischief. To this rule, however, exceptions ought to be made. A slight depression, especially when it corresponds to the thicker parts of the injured bone, does not require an immediate operation. Neither does a deep in-driving of the bone over the frontal sinuses; but here it must be borne in mind that these sinuses do not begin to make their appearance until several years after birth. And should a compound fracture with depression chance not to fall under the notice of the surgeon until some days after the accident, he ought, if there are no signs of inflammation, to abstain from operating; and all the more readily, if the depression is a broad one, and the fracture comminuted. In such an injury the patient sometimes recovers without any intra-cranial inflammation. But in the punctured fracture, in which sharp splinters of the inner table are driven down upon, or into, the dura mater, inflammation almost invariably arises sooner or later; and of all compound fractures of the skull, the punctured fracture is on this account the most dangerous, and the one which most imperatively calls for the use of the trephine. And closely allied to these punctured fractures are those in which a clean cut exists in the outer parts of the bone, with a more or less extensive splintering and depression of the inner plate. True it is that there may be some difficulty in such cases in ascertaining the exact condition of the bone; but we may be sure that the two plates are separated from each other, and the inner one splintered and depressed, if we can pass a probe sideways under the outer parts of the cut bone, and then feel the inner plate some distance deeper.

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* *Med.-Chir. Trans.* vol. xiv. pp. 401, 402.

Sometimes, in these compound fractures of the skull, and especially in the punctured fracture, a sharp fragment of bone may be seen sticking in the brain. In such a case, one of Colles'* practical precepts is, that all attempts at removal should be postponed for a few days, in order that the cerebral substance around the fragment may have time to consolidate; but in such a case I cannot help thinking that it is better to try and remove the piece of bone, which sometimes, even, comes away readily enough. In these attempts the surgeon should, however, be exceedingly careful; and should he find the fragment, notwithstanding all his care, sinking deeper into the brain, then there is no doubt that he ought at once to desist, and make no further attempt for a few days.

In the fractures which we have been considering, operative interference may be, and often is, of essential service; but thus far we have dealt with the most favourable cases only—those cases in which the injury of the bone was not accompanied by brain-symptoms.

Passing now to those depressed fractures in which there are primary brain-symptoms, are we to operate in all such cases? If the fracture is a simple one, and the symptoms not very urgent, we may postpone the operation, and see what can be done by other remedial measures, before resorting to the trephine. Slight symptoms may perhaps be dependent upon concussion of the brain, or upon some slight pressure, either by blood or by bone; and such symptoms may pass off under the influence of judicious treatment. But if the symptoms are urgent—if they indicate a decided pressure upon the brain—then operative interference becomes necessary.

And, from what has already been said, it follows that, with a wound leading down to the bone, we ought to operate at once. If the symptoms are slight, the operation may be successful;

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* *Lect. on Surg.* vol. i. p. 173.

but if the symptoms are urgent—if compression of the brain is decided and strongly marked—there is every probability that all our efforts will be unavailing; for in such cases it very rarely happens that the brain-symptoms are dependent upon the depressed bone. The severe symptoms in fractures with depression arise, for the most part, from extensive extravasations of blood, or some serious lesion of the brain substance itself; and hence the reason of an operation being so seldom of any use. Still, notwithstanding all this, it is our duty to operate, as the symptoms may, after all, be wholly dependent upon the bone. Cases are certainly now and then met with in which symptoms of a very urgent nature persist so long as the bone remains depressed, and are relieved only by its removal. Of this, the most remarkable case is Cline's,* in which the symptoms continued for the extraordinary period of thirteen months, and still were relieved by the removal of the bone.

As a general rule, a depressed piece of bone may be allowed to remain in a child without producing the serious results so commonly noticed in an adult; and, consequently, we may in a child postpone the elevation or removal of the broken bone, which in an adult we should proceed to operate upon at once.

In operating for a fracture with depression, the only object is to elevate or to remove the fragments which are driven down. Now if this can be done by means of the elevator only, so much the better. Should this not be feasible, then we must see if we can gain sufficient room for the elevator by the removal of a slip of the sound bone overhanging the depressed fragment; and this is to be done by Hey's saw, if possible. The use of the trephine, as far as depressed bone is concerned, is to be restricted to those cases in which the edge of the fracture is regular, and without corners. And in trephining, great care should be taken to remove as little bone as possible; but, in our anxiety not to remove too much, we must be especially careful, and be sure that no irregular margin of the inner plate is left pressing upon the brain. In looking over the skulls in our different museums, it is curious and most instructive to observe how frequently a sharp edge of the inner plate of the bone has been left depressed.

After the removal of parts of the skull, it was the custom in former times to protect by plates of silver, or lead, or by some other means, the portion of brain thus left exposed. Of late years, however, this practice has been abandoned; and now, the protection of the brain is left to the thickened dura mater and integuments, for it rarely happens that ossification takes place sufficiently to fill up the gap. Patients, under such circumstances, may go on unharmed for years. Occasionally, however, the cicatrix gives way, hernia cerebri follows, and the patient dies. Thus it happened to a young girl, in a violent fit of coughing, during which the cicatrix suddenly gave way.*

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* *Med.-Chir. Rev.* vol. i. p. 471.

Finally, in a fracture of the vault, injury of a large venous sinus may occur; and in a compound fracture, such an injury may be followed by hæmorrhage of an alarming character. But, however alarming such bleeding may at first sight be, it is generally said that the danger is more apparent than real; the bleeding may be profuse, but it is easily controlled. Indeed, M. Chassaignac † states, that he had not been able to find on record a single instance of fatal hæmorrhage from a sinus thus wounded. There is, however, in the Museum of St. George's Hospital a preparation of a compound fracture of the skull laying open the left lateral sinus (Figs. 48, 49); and in this case, the patient, a powerfully-built man, aged 51, died of repeated attacks of hæmorrhage.

An injury of one of these venous sinuses may also lead to fibrinous deposits within the sinus, and suppuration with all its secondary consequences. And pyæmia may, as a matter of course, follow any fracture of the vault; but pyæmia is much more frequently met with in the slighter injuries — scalp-wounds, or contusion of the bone. Thus in twenty-three cases of simple scalp-wound or contusion of the bone, which ended fatally at St. George's Hospital within the space of ten years, purulent infection was noticed in fourteen instances; whereas in seventy-eight cases of fracture terminating fatally within the same period, it was noticed in six cases only; and even of these, five were compound fractures. The fact is, that in far the greater number of fractures the patient dies long before the period at which purulent infection usually sets in.

Fractures of the base. Fractures of the base of the skull are either direct or indirect; that is, the bones either give way at the spot which was actually struck, or at a point more or less remote from the seat of the injury.

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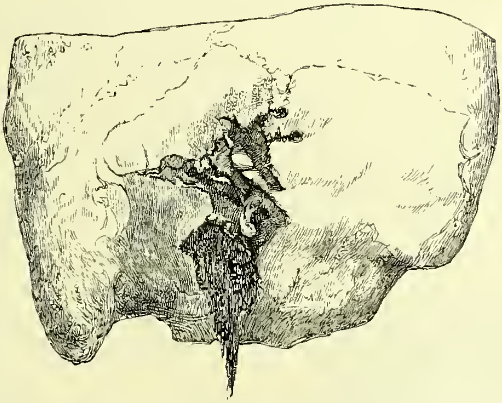
* *Edin. Med. Essays*, vol. ii. p. 217.

† *Des Plaies de Tête*, 1842, p. 79.

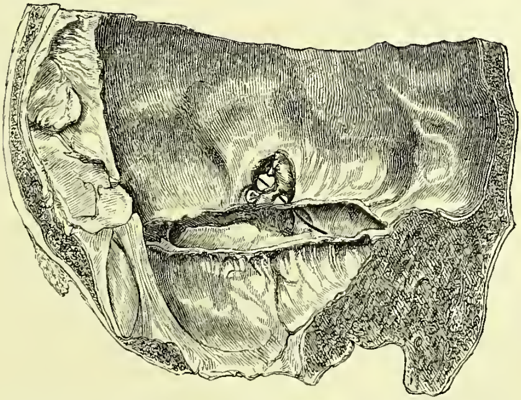
FIG. 48.



Compound fracture of the skull—laying open the lateral sinus.
Outer view.

In the vault, fractures are, as we have seen, for the most part direct; but in the base, direct fractures are, comparatively speaking, very rare.

FIG. 49.



Compound fracture of the skull—laying open the lateral sinus.
Inner view.

At certain parts, however, the bones of the base of the skull are remarkably thin and brittle; so thin, that if direct pressure is brought to bear upon them they readily give way. Thus scissors, slate-pencils, tobacco-pipes, bayonets, have been thrust into the skull through the orbits, the nostrils, and the occipital bone; and the condyle of the lower jaw has even been driven into the middle fossa of the skull.

Thrust-wounds in these regions, and especially those of the orbits and of the nostrils, are of great importance, from the readiness with which the brain may thus be injured.

Injuries of this kind occur most frequently about the orbits, and in no class of cases is the surgeon more likely to be put off his guard as to the exact nature and extent of the injury. At first, all that may be apparent is the slight injury of the external parts—a trifling wound of the upper lid, and sometimes not even this, for the instrument may have slipped under the lid, and left merely a patch of ecchymosis on the conjunctiva. Brain-symptoms there may be none. Two or three days may pass over, during which the patient goes about as usual; then, brain-symptoms make their appearance, sometimes suddenly, and the patient dies in the course of a few hours, or days, and the true nature of the case is revealed only by the post-mortem examination. Such is the history of the cases recorded by Morgagni,[*] Sir A. Cooper,[†] Sir P. Crampton,[‡] Guthrie,[§] and J. Painter.[||] In other cases, recovery has taken place notwithstanding serious injury of the brain, indicated by severe brain-symptoms,[¶] or by brain-protrusion.[**] One such case of recovery is constantly quoted, in which it has, however, been made clear that the brain could not have been injured. François de Lorraine, Duc de Guise, is represented[††] as having recovered after a lance had passed immediately *above* the eyeball, and through a part of the skull. But on referring to the report of the celebrated Ambroise Paré,[‡‡] who had charge of the case, it has of late been proved that the lance did not pass *au-dessus*, but *au-dessous de l'œil;* and, consequently, that the skull was not even injured.

What has just been said of direct fractures of the orbit applies equally to thrust-wounds through the nostrils. Whilst fencing with a walking-cane with one of his comrades, a soldier was hit on the nose; but the only appearance of injury was a small puncture, not larger than a leech-bite, on the left ala. The man died a few days afterwards, with brain-symptoms; but the exact nature of the case was never even suspected. At the post-mortem examination, however, the brass ferrule of the walking-cane was found in the skull, close to the left side of the sella turcica, and this had led to extensive inflammation of the membranes of the brain.*

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[*] Lett. 51, vol. iii. p. 121.

[†] *Lect. on Surg.*, Tyrell, vol. i. p. 295.

[‡] *Dublin Jour.* 1851, p. 352.

[§] *Inj. of Head*, p. 137.

[||] *Dublin Jour.* 1851, p. 353.

[¶] Morgagni, Lett. 51, vol. iii. p. 123.

[**] *Lancet*, 1837-38, vol. ii. p. 16.

[††] Boyer, *Mal. Chir.* t. v. p. 83, 4^{e} édit.

[‡‡] *Œuvres de Paré*, édit. Malgaigne, Paris, 1840, t. ii. p. 25.

A direct fracture of the base has also happened by the condyle of the lower jaw being forcibly driven against its fossa, the diaphanous plate of which it has broken through. Of this fracture there is a specimen in the Museum of St. George's Hospital. The bottom of the left glenoid fossa is broken, and the condyle of the jaw projects slightly into the cavity of the skull. But a still better-marked case is that quoted by M. Chassaignac,† in which the right condyle of the lower jaw was driven into the skull by a fall from a great height on to the chin. The man lived for between five and six months, during which he always complained more or less of his head, and ultimately

Fig. 50.

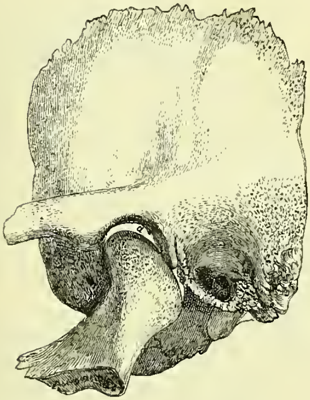
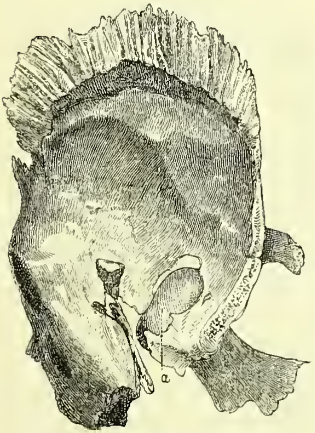


Fig. 51.



Fracture of the skull, caused by the condyle of the jaw.

a shows the condyle projected slightly into the cavity of the skull.

Outer surface. *Inner surface.*

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* *Dublin Jour.* 1851, p. 347.

† *Plaies de Tête,* p. 158; *Jour. Hebd.* t. iii. No. 37, Sept. 1834.

died with brain-symptoms. The right condyle of the lower jaw was found pressing against the middle lobe of the brain, in which there was a large abscess.

And now as to indirect fractures of the base of the skull. These fractures are very common; so much so, indeed, that they form by far the greater part of the fatal injuries of the head occurring in our civil hospitals. Such fractures were, for the most part, and for a long time, looked upon as fractures by contre-coup. But modern researches have proved that fractures by contre-coup are very rare at the base of the skull; and a close analysis of fractures of the base shows that the bones of this region may be broken in different ways.

A blow upon the perpendicular portion of the frontal may give rise to a fracture of the orbitar plate of this bone, without any injury whatsoever being perceptible in the intervening osseous tissue. Of this an example happened at St. George's Hospital in the year 1849, and a very similar case is related by Boyer.*

The central bones of the base may be the only bones broken when the front and back part of the head have been caught between two opposing forces.

Fractures of the base may also be produced by the force acting from below upwards, the shock being transmitted through the intermedium of the spinal column; and, as in the previous instances, the bones broken may be far away from the spot which was struck. Alighting on the knees, or on the feet, in falls from great heights, gave rise, in one instance,† to a breaking off of the apex of the right petrous bone, and of both posterior clinoid processes; in another instance,‡ to a fracture also of the right petrous bone, and a slight fracture of the same side of the sella turcica; and in a third instance,§ the only bone broken about the skull was the cribriform plate of the ethmoid; every other bone in this region was perfectly sound.

But fractures such as these are, one and all, of rare occurrence, and but very few such cases are recorded by modern surgeons.

Impulsion of the spinal column forcibly against the condyles of the occipital bone is supposed by some surgeons to be the cause of the fractures so frequently observed at the base of the skull. Such was Earle's opinion,* and Sir B. Brodie states that his own experience corresponds very nearly with that of Earle; and lately, Mr. Hilton, in his valuable *Lectures on the Cranium* (p. 61), comes to the conclusion that the frequency of the fractures occurring through the petrous bone is dependent upon the forcible impulsion of the spine against the occipital bone.

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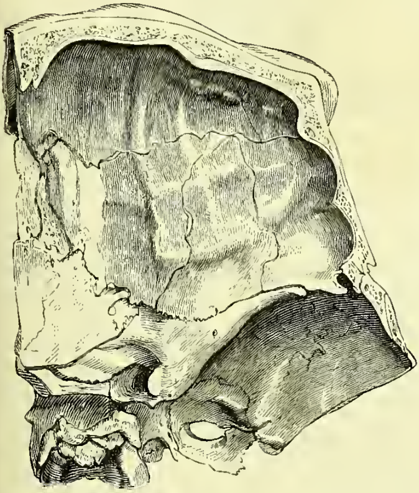
* *Journ. de Méd.*, août 1766, Paris.

† *Journ. l'Expér.*, novembre 1843.

‡ *Bull. de la Soc. Anat. de Paris*, 1848, p. 193. § Id. 1848, p. 258.

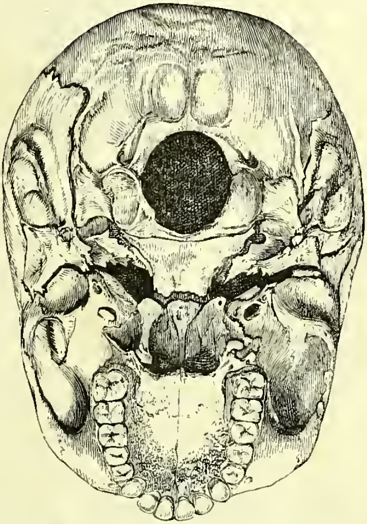
That certain fractures of the base may be thus produced there is no doubt; but that most of the fractures of this region happen otherwise has, I think, been proved also beyond a doubt. A fracture of the base may be strictly limited to the front, middle, or back part of this region of the skull; and preparations illustrating these different fractures have for many years past been in the Museum of St. George's Hospital. But, as far as I know, Dr. Aran† was the first to prove, by experiments, how certain fractures came to be strictly limited to certain regions. In precipitating a large number of bodies from various heights on to the head, Dr. Aran found that the

Fig. 52.



Fracture limited to anterior fossa.

Fig. 53.



Fracture limited to middle fossa.

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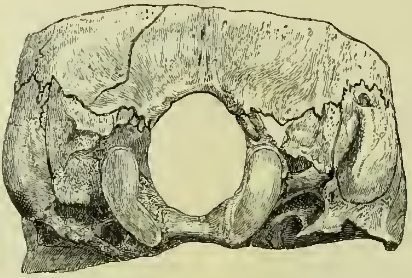
* Sir B. Brodie, *Med.-Chir. Trans.* xiv. p. 329.

† *Arch. Gén. de Méd.* iv^{e} sér. t. vi. p. 180.

part of the vault which first struck the ground gave, as it were, the key to the fracture which would take place at the base. Similar results were also obtained when diffused blows were dealt upon different parts of the skull by means of a large and heavy hammer.

In the front part of the vault, injuries thus produced led to a fracture of the anterior fossa: in the middle part of the vault, they led to a fracture of the middle fossa; and at the back of the head, to a fracture of the posterior fossa. In no single instance was a fracture detected at the base, without a line of fracture in the corresponding part of the vault.

Fig. 54.



Fracture limited to posterior fossa.

Taking, then, these experiments of Dr. Aran's, it will be found that the line of fracture, instead of beginning at the base, starts from that part of the vault which was first struck, and stretches from thence into the base. And the truth of this has been proved by an analysis which I made of all the cases of fractured base of the skull admitted into St. George's Hospital during a period of ten years, in the great majority of which the cause of the fracture was either a fall from a great height, or a blow from some heavy instrument.

But, to trace out these fractures accurately, the skull must be divided into three different zones or segments; an anterior zone, formed by the frontal, the upper part of the ethmoid, and the fronto-sphenoid; a middle zone, by the parietals, the squamous and the anterior surface of the petrous portions of the temporals, with the greater part of the basi-sphenoid; and a posterior zone, including the occipital, the mastoid, and the posterior surface of the petrous portions of the temporals, with a small part of the body of the sphenoid.

With the skull thus divided, the line of fracture, in the less severe cases, is strictly limited to one of these zones. Out of twenty-five cases, the line of fracture was found to be thus strictly limited: to the anterior zone in five cases; to the middle one in fourteen cases; and to the posterior one in six.

In severer cases, the line of fracture starting from the vault spreads into two of the fossæ at the same time, and this is readily accounted for by the position of the middle fossa, which, wedged in between, and firmly articulated with, the bones of the other fossæ, either receives or transmits the injury. Thus, out of twenty-nine cases in which the line of fracture occupied two of the fossæ at the same time, in fourteen it was the middle and anterior fossæ which were implicated; and in fifteen, the middle and posterior.

In the most severe cases, all three fossæ may be implicated at the same time; but, within the ten years, this happened only in ten cases.

Such an analysis points out, moreover, that the middle fossa, either alone or in combination with the other fossæ, is the region in which fractures most frequently occur. Out of the sixty-four cases, the middle fossa was broken in no less than in fifty-three cases.

In the severer forms of injury there may be, in various parts of the base, some small circumscribed fractures in addition to, and having no connexion with, the main line of fracture. Thus, the roof of the orbit is sometimes broken independently of, and away from, the principal fracture; and so, too, may the posterior clinoid processes be thus broken.

The only *symptoms* that can be depended upon as indicative of fractured base of the skull, are connected either with an escape of some of the contents of the skull, or with an injury done to the nerves as they are emerging from the skull.

The contents of the skull which may escape in a fracture of the base are blood, watery fluid, or brain-substance. The watery fluid and the brain-substance must be left for further consideration, and so, too, must the injury of the nerves. Remains then the escape of blood.

And now, in order that this escape of blood may take place, the line of fracture must run in certain given directions; it must in its course involve some of the large vascular channels lying at the base, and it must, moreover, open a road through which the blood can get out of the skull into some part where its escape may be visible. But should it so happen that the injury does not produce effects such as these, there may be a very extensive fracture of the base, the existence of which cannot be revealed until the post-mortem examination takes place.

A fracture at the base may manifest itself by an escape of blood into the cellular tissue of the orbit and eyelids; by bleeding at the nose, or subsequent vomiting of blood; by bleeding from the ears; by an escape of blood into the cellular tissue in the mastoid region, or into that of the back of the head.

A fracture involving the orbitar plates of the frontal, and extending into the sphenoid, may lay open either the venous channels in this region, or the ophthalmic artery—the former much more commonly than the latter.

The blood, at first poured out at the back of the orbit, soon makes its way forward; readily infiltrating the loose cellular tissue of this region, it first shows itself under the ocular conjunctiva, and subsequently spreads into the eyelids. First the ocular conjunctiva, then the lids; such are the points at which blood coming from the bottom of the orbit must show itself. But it is the effusion of blood under the ocular conjunctiva which must guide us in our diagnosis, and for this purpose the effusion must not consist of a few patches only; it must extend into the cellular tissue of the orbit beyond our sight. As to the lids, the lower one generally becomes discoloured before the upper one. M. Velpeau thinks that the lower lid is always the first to be discoloured; but I have seen several cases of fractured base in which the ocular conjunctiva and the upper lid were ecchymosed without any discoloration of the lower lid.

Effusion of blood under the ocular conjunctiva is, then, the sign by which a fracture of the front part of the base may be recognised. But a fracture of this region may exist without any effusion of blood under the ocular conjunctiva, or the lids only may be discoloured; and in such cases it must be borne in mind that, however extensive the fracture, it cannot be diagnosed.

Out of twenty-three cases of fractured base, involving more or less extensively the orbitar plates of the frontal, all of which occurred at St. George's Hospital within the space of ten years, it was found, in eight cases, that there were no traces of extravasated blood to be seen either in the eyelids or under the ocular conjunctiva; and in five cases, that the effusion of blood occupied the eyelids only: so that in these thirteen cases there could have been no suspicion whatever as to the existence of a fracture. But, on the other hand, the nature of the injury was made manifest in the ten remaining cases by the blood effused under the ocular conjunctiva and in the lids.

Blood may, however, be effused into the lids, and under the ocular conjunctiva, in fractures of the malar, or of the superior maxillary, bones; and this may give rise to an error in diagnosis. But such cases are of rare occurrence. One was published some few years back by Mr. Holmes.*

Effusion of arterial blood at the back of the orbit, in consequence of a fractured base, is of further interest, inasmuch as it may ultimately lead to a traumatic aneurism, which may go on increasing in size, and thus imperatively call for surgical interference.

Three such cases have occurred, within the last few years, to London surgeons; two at the London Hospital itself, and one at the Seamen's Hospital. In all these three cases, the history and the symptoms left no doubt as to the nature of the injury: in all three, a ligature was ultimately applied to the common carotid, and in all three recovery followed this operation.†

Bleeding from the nose or mouth, or vomiting of blood, occurs, not unfrequently, after injuries of the head; but the great vascularity of the membrane lining these cavities renders this bleeding much less valuable as a diagnostic sign of fractures of the base than that which proceeds from the ear. Still, if the bleeding be copious, and especially if it continue for some time, there is no doubt that it then becomes a symptom of great value as a means of diagnosis. Out of thirty-two cases of fractured base, implicating the central bones of this region, all of which occurred at St. George's Hospital in the space of ten years, bleeding from the nose or mouth, or subsequent vomiting of blood, was present in no less than in fourteen instances. The symptoms in these cases were such as to lead to the belief that a fracture existed in some of the bones of the base corresponding to the pharynx or nose; and dissection proved that out of the fourteen cases, the fracture was confined in four cases to the ethmoid; in three, to the body of the sphenoid; and in one, to the basilar process. In five cases, the fracture involved both the ethmoid and the sphenoid; and in one case it extended not only through these bones, but through the basilar also.

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* *Association Medical Journal*, 1855, p. 967.

† *Med.-Chir. Trans.* vol. xxii. pp. 124-134; xxxvi. p. 221.

In the vomiting of blood, proceeding from a fractured base, it not unfrequently happens that the fluid thrown up is of a dark bistre colour; having been swallowed and retained in the stomach for some time, the blood has, in fact, been more or less acted upon by the gastric juice. Such appearances I have several times noticed when vomiting occurred after the subsidence of the symptoms of concussion which accompanied the fractured base.

Bleeding from the ears, in severe injuries of the head, has, for many years past, been held, and deservedly too, as one of the most valuable diagnostic signs of fractured base. But this bleeding, to be of any value as a means of diagnosis, must be of a serious nature, and, above all, it must continue for some time. With such a bleeding, it may be safely diagnosed that there is a fracture of the base running through the petrous bone, and opening up a communication between the cavity of the tympanum and some of the numerous and large vascular channels which surround this bone, or with an extravasation of blood within the cranium itself.

Out of thirty-two carefully dissected cases of fracture of the middle fossa implicating the petrous bone, the flow of blood from the ear was profuse and continuous in fifteen cases, and in all these cases the diagnosis of the injury was clear.

On the other hand, fractures of the temporal bone frequently occur in which there is no sign that can lead to the supposition of such an injury. In such cases, either the line of fracture does not extend into the tympanum, or, if it does, the membrana tympani is not ruptured, and the blood cannot consequently get into the external meatus. Thus, in twelve of the seventeen remaining cases, the tympanum was not involved in the fracture, and in the other five cases the tympanum was fractured, but the membrana tympani was not ruptured.

In those cases in which a fracture of the petrous bone communicates with one of the venous sinuses on the inside of the skull, and in which there is no rupture of the membrana tympani, there can be no bleeding from the ear; but, in such cases, the blood poured into the cavity of the tympanum soon finds its way through the Eustachian tube, so that there may be bleeding from the nose or from the mouth, or subsequent vomiting of blood. Of this, careful dissections leave no doubt. And this passing of blood from the cavity of the tympanum through the Eustachian tube may even take place when there is a rupture of the membrana tympani; so that, in some few cases of fractured petrous bone, we may actually have bleeding both from the ear and from the nose at the same time.

Extravasation of blood, and consequent discoloration of the skin, appearing in the mastoid region some hours after a severe injury of the head, may lead to the suspicion of a fracture involving the posterior part of the base; and all the more valuable will this sign become, if the injury did not bear directly upon this region, and especially if it bore upon the opposite side of the head.

A discoloration of the integuments of the lateral parts of the neck, appearing subsequent to an injury of the head, may also serve as a guide to the diagnosis of a fracture of the base. The blood oozing from the fractured skull gradually infiltrates the cellular tissue of the neck, and thus ultimately reaches the skin, which becomes discoloured, as if bruised.

And a sudden puffiness in the occipital region, with discoloration of the skin, some hours after a severe injury on this part of the head, may also be of use in the diagnosis of a fractured base. The large venous sinuses connected with the occipital may, when this bone is broken, be torn across, and thus give rise to an extravasation of blood, which, gradually oozing through the line of fracture, may ultimately show itself in the superficial parts, and thus reveal the nature of the injury.

Fractures of the base of the skull, even when clearly recognised, lead but very seldom to operative interference. All our treatment must be directed, not against the broken bones, but against the accompanying cerebral lesions. In some rare instances we may, however, have to resort to an operation, even in the base of the skull. Thus in a comminuted fracture, with depression, I have seen a fragment removed which proved to be the greater part of the roof of the orbit. And the trephine has been applied, and successfully too, close to the foramen magnum.*

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* *Med.-Chir. Trans.* vol. ii. p. 105.

What occurs about the broken bones, when the patient survives a fractured base? Does union take place? And if so, by what medium are the broken bones united?

In some cases, even after a lengthened period—months, and years—no trace of union has been found. In other cases, the line of fracture has been found united partly by dense fibrous tissue, and partly by a thin layer of inlaid bone. And in other cases, again, bony union has been perfect, and throughout the whole line of fracture. In some cases of bony union, porous bone has been found heaped up along the sides of the line of fracture on the inner side of the skull; and when the fracture passes through one of the sinuses, this heaping up of bone may be such that the channel becomes blocked up.

Separation of the sutures. A question has arisen whether a separation of the sutures can possibly occur, without the bones being in some way or another broken. As might well be supposed, from the nature of the articulations about the skull, a separation of suture without a fracture is a very rare form of injury. I have observed it but once. It occurred in the back part of the squamo-parietal suture. The temporal having been slightly separated from the parietal, and driven upwards, these bones presented at first sight the appearance of a fracture with depression.

In every other case in which I have met with a separation of the sutures, it has always been in connection with extensive fractures stretching into the base. Thus, in seventy-eight cases of fractured skull, there were fourteen cases in which there was extensive separation of the sutures, two or more of which were sometimes implicated at the same time.

As to the frequency with which the various sutures give way, an analysis of these fourteen cases proves that separation of the coronal suture occurred in seven cases; in the lambdoid, it occurred in six cases; in the sagittal, in four; in the petro-occipital, in one; in the temporo-parietal, in one; and in the spheno-parietal, in one. It sometimes happens, when several sutures have given way at one and the same time, that a whole bone becomes detached from the other bones. Thus, in one case where there was complete separation of the coronal suture, the frontal was at the same time extensively separated from its connections with the other bones of the skull, and thus all but isolated.

This separation of the sutures is, as a matter of course, most likely to occur before the adult period of life, and when the bones have not yet been soldered together. It has, however, happened at an advanced age, as proved by a case of Morgagni's,* in which the patient was sixty years old.

Coexisting, as separation of the sutures for the most part does, with extensive fracture of the base, this injury must be classed among the most dangerous to which the skull is subject. It invariably indicates that great violence has been done to the bones. Oftentimes it is accompanied by laceration of the pericranium, and separation of the dura mater; sometimes even by extensive laceration of both these membranes, through which the brain-substance may be squeezed out of the skull, and found lying immediately under the integuments.

A most extensive separation of the sutures, with fracture of the bones, may, however, take place without any injury of the cerebral substance. Of this, I once dissected a most remarkable instance. The skull was extensively broken; the two parietal bones were widely separated from each other, and on a different level in the whole length of the sagittal suture; the left bone was in its natural position, but the right was driven down about two lines. The brain itself was not in the slightest degree injured.

Disjunction of the sutures, in its symptoms and treatment, cannot be separated from fractures of the skull.

WATERY DISCHARGES IN CONNECTION WITH SEVERE INJURIES OF THE HEAD.

As an accompaniment of severe injuries of the head, a thin watery fluid is now and then found issuing either from the ear, or from the nose, or from some part of the vault of the skull.

From the ear. The watery discharge from the ear is that most commonly met with. As early as the year 1727, Stalpartius van der Wiel † published a case in which large quantities of a thin, clear, watery fluid had escaped from the ear, for several days, after a severe injury of the head. This case, and another quoted by Stalpartius from Joël Langelottus, are the only cases usually referred to as having been observed by the older surgeons; but O'Halloran,* some thirty years later, also published a case of the same nature, and in some respects even more characteristic; and the elder Dease† appears likewise to have been well acquainted with the occurrence of this peculiar watery discharge from the ear. But, notwithstanding the striking nature of these facts, the subject was subsequently lost sight of until some twenty years back, when M. Laugier,‡ by some carefully-made dissections, first brought to light the coexistence of this watery discharge from the ear with a fracture of the petrous bone and a rupture of the membrana tympani; and then followed the question, even now so much debated, as to the possible source of this fluid.

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* Lett. 51, art. 28.

† *Observat rarior. cent. prior.*, obs. xv.

The various opinions which have been broached upon this point may, however, be reduced to two classes: one, in which the fluid is said to be nothing but the serum of the blood; the other, in which it is said to be the secretion from some membrane.

This fluid was at first thought to be nothing but the serum from a clot of extravasated blood lying over and in direct contact with the fracture. Such was M. Laugier's first opinion, published in the year 1839, to which he has latterly added the 'exudation of serum from the lacerated vessels lying along the broken bone, and the neighbouring soft parts.'§ M. Chassaignac also thinks that the fluid is due to the serum of the blood, but that it oozes through a fraying of the thin outer wall of some one of the large venous sinuses connected with the petrous bone.||

Neither of these opinions has, it must be confessed, been borne out by subsequent experience.

The fluid has, in turn, been ascribed to one of the several secreting membranes with which the petrous bone is so closely connected. It has been thought to be the liquor Cotunnii; then the fluid from the cavity of the arachnoid; then, again, the cerebro-spinal fluid.

That the discharge is due, in some cases at any rate, to the escape of the cerebro-spinal fluid, there is now no longer any doubt. First mooted by Auguste Bérard and M. Nélaton,¶ this

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[*] *Inj. of the Head*, p. 120.

[†] *Colles' Lect.*, by M'Coy, vol. p. 155.

[‡] *Comp. Rend. de l'Acad. des Sc.* 1839, p. 240.

[§] *Arch. G. de Méd.* iv^{e} sér. t. viii. p. 413.

[||] *Mém. de la Soc. de Chir. de Paris*, tom. i. p. 542.

[¶] *Compend. de Chir. Prat.* t. ii. p. 591.

opinion was subsequently taken up and thoroughly investigated by M. Robert.* Anatomy, dissection of morbid specimens, experiments on the dead subject, all led to the conclusion that the watery discharge from the ear, after a severe injury of the head, is due to the escape of the cerebro-spinal fluid. And M. Chatin,† in analysing this watery discharge, found its composition to be the same as that of the cerebro-spinal fluid, both being especially marked by the very small quantity of albumen and the large quantity of chloride of sodium.

The escape of the cerebro-spinal fluid implies a fracture cutting across the meatus internus and communicating with the tympanum, a laceration of the tubular sheath of the cerebral membranes surrounding the seventh pair of nerves within this meatus, and a laceration of the membrana tympani. Of these various lesions, the only one about the proof of which there has been any difficulty is the laceration of the cerebral membranes within the meatus. There is, however, in the Museum of St. George's Hospital, a preparation which I dissected some years back, and which leaves no doubt upon this point.

But there are many cases in which dissection proves that the fracture has nothing to do with the meatus internus; whatever its course, either across or perpendicular to the axis of the petrous bone, the fracture passes through the internal and middle ear without touching the meatus. In such cases, it is clear that the watery discharge cannot be due to the escape of the cerebro-spinal fluid. It is then said, by many surgeons,‡ to be the liquor Cotunnii proceeding from the membrane of the labyrinth; and difficult, indeed, would it be, in many cases, to prove that the watery discharge is not in part due to this fluid, where the fracture runs through both the internal ear and the tympanum, which are thus made to communicate with each other, their investing membranes being torn. In opposition to this view, we have, however, the quantity of the fluid, which oftentimes is so great that we can scarcely realise the idea of its being all furnished by a membrane of so limited an extent. And to this we may add those cases of profuse watery discharge from the ear, after a severe injury of the head, in which it has been proved that there was no fracture involving either the internal or the middle ear, and no communication whatsoever between these cavities.

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* *Mém. de la Soc. de Chir. de Paris*, t. i. p. 562. † Id. p. 568.

‡ *Dict. de Méd.* 2e édit. t. xxix. p. 570.

Such a case occurred at St. George's Hospital in the year 1854. The man, having fallen off a ladder about twenty feet high, was admitted with a discharge of bloody fluid from the left ear, and a scalp-wound, not exposing the bone, at the upper and back part of the head. He died on the seventh day after the accident, with diffuse cellular inflammation of the scalp, and symptoms of cerebral mischief. As to the fluid from the ear, on the morning following the accident it was of a roseate hue, and flowing so freely that in less than an hour a couple of ounces were caught in a gallipot placed under the ear. The discharge went on thus for two days, the pillow-case being so soaked that it became necessary to have towels placed under the head. On the third day, the fluid was much less in quantity, and on the sixth there was but little of it, and it was of a puriform appearance. The temporal bone was carefully, and at several different times, examined both by Mr. Henry Gray and by myself. There was no fracture, and no injury whatsoever of the bone itself; there was no kind of communication between the middle and the internal ear; the membrane lining the cavities of the internal ear was perfectly natural in every respect; the membrane lining the cavity of the tympanum and the mastoid cells was intensely vascular throughout, and covered with a muco-purulent secretion; the membrana tympani was extensively ruptured at its anterior and inferior part. The case has been recorded by Mr. Henry Gray in the *Transactions of the Pathological Society of London*, vol. vi. p. 22. In this case there was no fracture; the watery discharge could not, then, be due either to the escape of the cerebro-spinal fluid or to an increased secretion from the arachnoid, or to a filtration of the serous part of the blood. There was no communication between the middle and the internal ear; it could not, therefore, be due to the escape of the liquor Cotunnii. But there was a rupture of the membrana tympani, and the membrane lining the cavity of the tympanum was intensely vascular; and this, I think, proves that, in this case, at any rate, the fluid proceeded from the inflamed membrane of the middle ear.

Another case of copious watery discharge from the ear, after an injury of the head and without any fracture of the temporal bone, occurred at St. George's Hospital a few years ago. The man was admitted with bleeding from the ear, which was followed by a copious watery discharge. He died; and on dissecting the temporal bone most carefully, Mr. Holmes could find no fracture in any part of it, and no injury whatsoever either in the tympanic cavity or in any part of the internal ear. The discharge was connected with fracture of the lower jaw just below the condyle: the lower fragment had perforated the wall of the meatus auditorius.

I have mentioned these two cases particularly to prove that cases do, now and then, occur in which an injury of the head has been followed by a copious watery discharge from the ear, without any fracture or injury about the petrous bone, or any communication between the middle and the internal ear.

What value, then, are we to attach at the present time to the watery discharge from the ear as a diagnostic sign of a fracture of the base? Can it now be said that a profuse watery discharge from the ear, after an injury of the head, is pathognomonic of fracture of the petrous bone? It must be confessed that we cannot say this. On the other hand, however, there is no doubt that the symptom still remains as one of great diagnostic value under certain circumstances.

A close examination of these cases of watery discharge shows that this fluid makes its appearance under different circumstances. In some cases, no discharge of blood, or only a very small quantity, precedes that of the watery fluid; the discharge is, in fact, watery, and unmistakably so, immediately after the accident. In other cases, a copious flow of blood, going on for some hours, precedes the watery fluid. In other cases, again, the flow of blood is decided, but to no great amount, and for no long period; and then, sooner or later, comes the watery discharge. There are, then, as far as is known at present, three classes of cases of this watery discharge.

In the first class, where the fluid from the ear is plentiful, and of a decidedly watery character immediately after the accident, there need be no doubt as to the nature of the injury,—the watery discharge is due to the escape of the cerebro-spinal fluid, which, as already stated, can only take place through a fracture of the petrous bone implicating the internal auditory canal and its membranes.

In the second class of cases, characterised by a copious and prolonged bleeding from the ear, followed by a watery discharge, a fracture of the petrous bone may also be safely diagnosed; but it cannot be said that the fracture follows any particular course. In these cases it must, however, be clearly understood, that it is not to the watery discharge that we can trust for our diagnosis, but to the copious and prolonged bleeding.

Thus far there is no difficulty. Not so, however, in the third class of cases, in which there is at first a discharge of blood only, neither copious nor prolonged, which is followed by a watery discharge, varying as to the time of its appearance—varying as to its quantity. It may be present within a very few hours after the accident,—it may be profuse within a very few hours after its appearance. These are the cases in which experience has, of late, proved that the diagnosis ought to be doubtful. The discharge of blood is certainly not of a character to warrant a diagnosis of fracture of the petrous bone; and as to the watery discharge, it is now well known that such a discharge may occur within a few hours after the accident, that its quantity may even be profuse, and yet that there may be no fracture.

It has been stated by some surgeons abroad, and especially by M. Robert,[*] that this profuse watery discharge, after an injury of the head, belongs especially to childhood and youth; but the cases which have fallen under my own notice, it so happens, have been for the most part beyond thirty years of age.

A profuse watery discharge from the ear has always been held as one of the very worst features in an injury of the head. At one time, indeed, so bad was this feature thought to be, that it was said that no patient ever recovered who presented this symptom. Such, in former years, was the opinion of the elder Dease,[†] and such, even in later years, was at one time the opinion of M. Robert.[‡] But Stalpartius' first case, in which, after an injury of the head, complete recovery took place, notwithstanding a most profuse discharge of a watery fluid, had evidently been forgotten for a time; and, of late years, several cases of recovery have been recorded.

In recording cases of recovery after this profuse watery discharge from the ear, we must, however, for the future bear in mind carefully to note the precise circumstances under which the discharge took place, and especially the precise characters of the fluid from its very first appearance. It must be particularly stated whether the fluid was watery from the beginning, or whether it was merely bloody; and then, whether the flow of blood was continuous for any length of time. And unless these points are carefully looked to, there will be some doubt as to recovery having taken place after a fractured base.

From the nose.—A discharge of a watery fluid sometimes takes place from the nostrils, after a severe injury of the head; but such a discharge occurs much less frequently from the nose than from the ear.

Attention was first called to this subject by a case which was under the care of Blandin, at the Hôtel-Dieu, in the year 1840.[§] The actual source from whence this fluid came was not clearly made out in this case; but in M. Robert's case,[||] which occurred in 1845, a careful examination proved that the dura mater lying over a fracture of the sella turcica was torn to the extent of about an inch, and that the visceral arachnoid corresponding to the anterior lobes of the brain was also torn. Moreover, some water dropt on to the sella turcica soon made its way into the nostrils, and, more especially, into the right side.

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[*] *Arch. Gén. de Méd.* ive sér. t. ix. p. 407.

[†] *Colles' Lect.* by M'Coy, vol. i. p. 155.

[‡] *Arch. Gén. de Méd.* ive sér. t ix. p. 409.

[§] *Gazette des Hôpit.* 1840, p. 205.

[||] Loc. cit. p. 590.

What are the characters of this watery discharge from the nostrils? Whenever carefully examined, the characters of this fluid have been found to be precisely similar to those of the profuse watery discharge from the ear belonging to our first class of cases. The fluid, then, is marked by its limpidness, and by its containing a large quantity of chloride of sodium, and little or no albumen; in fact, it is of the same nature as the cerebro-spinal fluid. M. Chassaignac,* however, sees here, as he did in the ear, nothing but a filtration of the serous part of the blood contained in the numerous venous sinuses in close connection with the body of the sphenoid, the fluid escaping from the sinuses through a fraying of their walls. But here again, the chemical analysis of the watery discharge differing so widely from that of the serum of the blood, makes it impossible to admit that such can be its source. Whence, then, does this fluid come? The anatomical disposition of the cerebral membranes in the central parts of the base of the skull is such that, doubtless, a fracture of this region might involve the membranes, lay open the great reservoirs of fluid contained in the corresponding sub-arachnoid space, and thus account for the enormous discharge of watery fluid observed in these cases; and which in M. Robert's case flowed in large quantities after death, upon the body being turned with its face downward. And in addition to the sub-arachnoid space, situated over the body of the sphenoid, there is also here, in the sella turcica, the pituitary gland, connected with the infundibulum, which is continuous with the third ventricle. So that at this spot the watery discharge from the nostrils might be due to the escape of the fluid contained in the ventricles, if the pituitary gland and infundibulum were lacerated or destroyed by the injury. And such, one may infer from the post-mortem appearances, was the nature of Blandin's case.

But it would also appear that, every now and then, this watery discharge from the nostrils may be connected with a fracture of the petrous bone. As the blood in a fracture of the petrous bone sometimes escapes through the Eustachian tube, so may the cerebro-spinal fluid poured into the cavity of the tympanum through a fracture implicating the internal auditory canal escape thus. One such case has been published by Dr. Foucard,* and another by M. Malgaigne,† in which a most copious watery discharge took place both from the ear and from the nostril, at the same time.

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* Loc. cit. p. 553.

In dealing with this watery discharge from the nostrils as a diagnostic sign of a fractured base, it must, however, be borne in mind, that not unfrequently a copious watery secretion, perfectly clear and limpid, is poured out by the pituitary membrane itself. Some persons, indeed, are subject to periodical attacks of this kind, during which a perfectly clear fluid is poured out from the nostrils, in very large quantities, and for several hours together; and this it is which makes it so difficult in some cases, evidently of fractured base, to give any opinion as to the source of the watery discharge which has existed.

From the vault of the skull.—A discharge of a clear, watery fluid, precisely similar in its character to the watery discharge from the ear and from the nose, may also take place from any part of the vault of the skull, provided the injury extend not only through the integuments and the bones, but also through the cerebral membranes; laying open, in fact, the space between the visceral arachnoid and the pia mater.

The watery discharge in these cases, as in some of the cases connected with the ear and with the nostrils, is due, then, to the escape of the cerebro-spinal fluid.

In his valuable paper on the subject of watery discharges from the head after injuries, M. Robert states, that the first case of watery discharge from the vault which fell under his notice occurred in the year 1847; and that, until he had seen this case, he had always thought that these watery discharges existed only in fractures of the base of the skull.‡

Cases of a watery discharge from the vault in compound fractures had, however, been noticed by some of our predecessors years ago; but the facts, as in the case of a watery discharge from the ear, remained buried in oblivion until the attention of the profession was especially directed to them by the many discussions to which this subject has of late years given rise.

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* *Journ. de Chir. de Malgaigne*, 1846, p. 315. † Ibid p. 283.

‡ Loc. cit. p. 596.

The earliest published case of this watery discharge from the vault is dated as far back as the year 1672. The child, about seven years old, was under the care of Delamotte; nothing untoward occurred, and in about a month's time the wound was perfectly healed. The fact of a watery fluid having been discharged through the wound is not mentioned in the history of this case; but, in his accompanying observations, Delamotte expressly states that he very much wished to apply the trepan in this case, and especially on account of a long kind of sinus leading from the wound on the forehead deep into the inside of the skull, from whence flowed a large amount of watery fluid, the quantity of which was much increased each time the boy was made to blow his nose.*

In a case which was under the care of Hey of Leeds,† in 1809, a watery fluid issued from a compound fracture of the forehead so copiously as to wet the child's nightcap considerably. The discharge gradually abated, and ceased about the end of three weeks.

In Dr. O'Callaghan's case ‡ there was also a copious flow of bloody serosity from a wound connected with a fracture of the frontal bone; and in Dr. Hofling's case § a compound fracture of the frontal bone was followed by a clear, watery discharge, which soaked through all the dressings, and oozed copiously and uninterruptedly for the space of eight days. Dr. Hofling published this case as one of chronic hydrocephalus luckily cured by the kick of a cow; but in the details of the case there is certainly nothing to prove that the child was threatened with the hydrocephalic affection which is said to have been impending.

But two of the most curious cases of watery discharge from the vault occurred after trephining for epileptic fits, apparently connected with injuries of the head. In one of the cases, Professor Dudley states that the watery discharge went on for three days and nights, and was so copious as to make it necessary to change towels, pillows, bolsters, and sheets, two or three times a day; and it was computed that the entire amount of the fluid discharged could not have been less than two gallons; and notwithstanding all this, the patient recovered.||

In M. Robert's case,¶ the draw-sheet was completely soaked through during the night; and, on the following morning, the lips of the wound were found to be slightly united, except at the posterior angle, where there was a small opening, through which was flowing a clear, watery fluid, perfectly limpid, and saltish to the taste. On the third day the watery discharge had ceased, the wound having united in its whole length; but shortly afterwards the wound gave way at its posterior angle, and the fluid immediately reappeared, and continued to flow for two days, when it finally ceased. The man ultimately got well.

In the seven cases above alluded to, there is every reason to believe that the

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*Mauquest Delamotte, *Traité Comp. de Chirurg.* vol. i. obs. 145, p. 544.

†*Surg.* p. 21. case 5.

‡ *Dub. Med. Press*, vol. xiii. p. 81.

§*Arch. Gén. de Méd.* Nov. 1837.

||*Amer. Journ. Med. Sc.* 1828, vol. ii. p. 491.

¶ Loc. cit. p. 596.

fluid was the cerebro-spinal fluid from the sub-arachnoid space; but there is no doubt that the watery discharge from the vault may proceed from the lateral ventricle. This has been proved by dissection, in a case where, after extensive sloughing of the brain, the parts had become covered with granulations; everything was apparently going on well, when a discharge of a watery fluid occurred from the wound; the fluid, perfectly clear and limpid, was traced to a minute opening buried in the midst of the granulations, from whence it came away in drops, and sometimes in a jet, at each pulsation of the brain. The man ultimately died; and at the examination of the head, the minute opening through which the watery discharge had taken place was found to lead directly into the left lateral ventricle, the fluid of which had thus escaped.* And it was from the ventricle, I think, that the fluid came in the case mentioned by Mr. Erichsen,† to whom I am indebted for the following additional notes. It was not till the nineteenth day after the accident that the fluid made its appearance: it came suddenly, and was discharged in such quantities that the pillow was completely saturated with it during the course of the night; after this the boy lived four days, during which large quantities of the same transparent fluid continued to flow from the wound; and, even on the day of his death, the fluid was still running profusely. Unfortunately, there are no notes as to any examination of the head in this case; but, with such a history, I think it more than probable that the fluid did not proceed from the sub-arachnoid space, but from the right lateral ventricle, the posterior horn of which, thinned by an accumulation of fluid, gave way, and thus allowed of the profuse watery discharge, which suddenly took place on the nineteenth day after the accident.

Another case in which the fluid also came, in all probability, from the lateral ventricle, has, since the above was published, been under my own care, in St. George's Hospital. It was that of a boy, aged seven years, who having just been run over by a light brougham, was admitted, in March, 1863, into the hospital, with a compound fracture of the right parietal, about two inches and a half above the ear. A triangular piece of bone had been completely broken off, and driven down, so as to be buried in the brain, and serous fluid was oozing through the wound. As the bone could just be felt with a probe, it was laid hold of with a pair of dressing forceps, and pulled out; it measured about an inch and a half in length, and being turned lengthways, it had, in all probability, torn the lateral ventricle, from whence came the fluid, which soon became perfectly clear and limpid, and went on increasing in quantity, so that on the second day after the accident, in addition to a quantity which was lost, no less than four ounces and a half were collected within twenty-four hours. The fluid went on running thus until the sixth day after the accident, soaking the towels under the side of the head, when it began to diminish somewhat in quantity, and, on the tenth day, it was reduced to an occasional drop running down the cheek. Matters went on thus for a few days more, when the fluid ceased altogether, and the child was discharged from the hospital, cured, with the wound completely healed, seven weeks after his admission. I have seen this boy again lately, that is six years after the accident, and, barring the gap in his skull, where the brain can be felt pulsating, there is nothing the matter with him.

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* *Bulletin de la Soc. Anat. de Paris*, année 1838, vol. xiii. p. 13.

† *Surgery*, 2d ed. p. 276.

A case of escape of cerebro-spinal fluid, in connection with a simple fracture of the frontal bone just above, and including the orbitar arch, has just been published by Mr. Warrington Haward,* which presents peculiar features. As the fracture was not compound, the fluid escaping under the integuments formed a transparent pouch, with distinct pulsation, in the region of the blow, and in four or five days great swelling of the upper eyelid, and eversion of the palpebral conjunctiva. The tumour was ultimately punctured with a very fine trocar, and eight ounces of clear fluid were drawn off, leaving the sac empty, but it soon filled again, the little wound having been closed up. On the eighth day after this, the everted conjunctiva gave way, and a large quantity of clear fluid escaped, and went on running, so that it was computed that about a pint of fluid was thus lost in twenty-four hours. The child ultimately died of cerebral symptoms, but the only part of the body of which the parents would allow an examination was the portion of broken bone, where a gap was found between the fragments, and here there was a rent in the membranes, through which the handle of a scalpel was easily passed into the brain.

What influence is the escape of the cerebro-spinal fluid through a fracture of the skull likely to exercise on the ultimate issue of the case?

Looking to fractures of the base only, it might at first sight be supposed that the escape of the cerebro-spinal fluid would exercise a most dangerous influence on the progress of the case. It cannot in truth be said, however, that the danger in these cases is dependent upon the escape of the cerebro-spinal fluid. The danger lies not in the gradual loss of the fluid, but in the severe lesions, extravasations of blood, and injuries of the brain-substance, which so commonly accompany a fractured base.

But, in looking to the compound fractures of the vault of the skull, in which the brain is oftentimes not injured, there we shall find that large quantities of this cerebro-spinal fluid may be lost, and that apparently without influencing the case very materially.

Out of the eleven cases of watery discharge from the vault to which I have alluded above, eight recovered; and the details of these eight cases which recovered clearly prove that the watery discharge, however copious, did not appear to have any material effect.

And hence the broad plan of treatment in each case of watery discharge connected with an injury of the head is to be based upon the general symptoms which may exist. These cases must therefore be treated as any other severe injury of the head; the various symptoms, whatever they may be, must, in fact, be dealt with as they present themselves.

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* *Lancet*, July 17, 1869, p. 79.

CONCUSSION OF THE BRAIN.

A man receives a blow on the head, by which he is only stunned for a longer or a shorter period. What is said to have happened? Concussion of the brain.

A man dies instantaneously, or lingers some time perfectly unconscious, after an injury of the head; there are no marks of external violence. Again, what is said to have happened? Concussion of the brain.

The head is opened, and what is found? In one case, no deviation from the healthy structure; in another, simply great congestion of the cerebral vessels; in another, numerous points of extravasated blood scattered throughout the brain-substance; in another, a bruised appearance in some parts of this organ. In all, the case, in common parlance, is said to have been one of concussion of the brain.

Such are the after-death appearances ascribed by different surgeons to concussion of the brain.

The teaching of the different schools, then, is, that in simple concussion we may either find nothing in the brain to prove that this organ has sustained any injury, the brain-substance and its membranes appearing to be perfect in all their parts, or we may find certain lesions, plainly showing how much the cerebral substance has suffered.

But it behoves us carefully to examine and see how far we are justified nowadays in admitting that these various appearances do really belong to simple concussion of the brain.

And first, as to those cases of instantaneous death ascribed to concussion of the brain, in which no deviation from the healthy structure of the cranial contents is detected.

A century and a half ago was published* the first case in which it was clearly and distinctly stated that concussion of the brain may prove instantaneously fatal, without there being, on dissecting the brain, a single trace of injury in any part of the cerebral substance or of its coverings. And this is the celebrated case of Littre, to which reference is always made, even in the present day, to demonstrate that simple concussion of the brain may be followed by instantaneous death; and yet, strange to say, the details of this case afford literally no proof whatever that the man was actually killed by concussion of the brain.

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* *Mém. de l'Acad. des Sciences,* 1705, p. 54.

The case stands thus: a malefactor, young and strong, who had been sentenced to be broken on the wheel, determined upon destroying himself. Head foremost, and with his hands behind his back, rushing a distance of fifteen feet across the prison-cell, he dashed his head against the wall, and dropped down dead. On removing the skull-cap, everything was found in its natural condition, and, in fact, perfectly healthy, save that the brain did not nearly fill the cavity of the cranium, as it usually does, and that its substance, as well as that of the cerebellum and of the medulla oblongata, was, both to the touch and to the sight, closer and more compact than usual. And, by way of explaining the sudden death, M. Littre adds, 'From the violence of the shock, the brain had shrunk considerably; and, possessing but little elasticity, it could not recover itself, in consequence of which the distribution of the nervous influence throughout the body failed in an instant.'

Such is Littre's case, upon which so much reliance has been placed, as affording the strongest proof that simple concussion of the brain may lead to sudden death. But what is there in this case to prove that this malefactor did really die of concussion of the brain? Nothing but the head was examined; and here, even, very little care appears to have been taken to ascertain the exact condition of the brain-substance, and no allusion is made to the cerebro-spinal fluid. And, above all, what is to be said of Littre having, in such a case of sudden death, omitted to examine both the spine and the heart?

Does not the very history in Littre's case at once suggest the idea that this man did not die of concussion of the brain, but of a broken neck? And yet this part was never even thought of. What value should we, in the present day, attach to an examination thus carried on in our own dead-houses? Few of us would, I think, hesitate to say that such an examination proved nothing. And if this be the case, why should we accept from Littre that which we should refuse to accept, under similar circumstances, from any living surgeon?

With its few details and its capital omissions, Littre's case is, then, to me, I must confess, of no value. And such, too, are the conclusions arrived at by M. Fano, who has of late been making some extensive and well-planned researches on the subject of concussion of the brain.

The same may, strangely enough, be said of every other case which has been brought forward to prove the all-important doctrine that concussion without lesion of the brain-substance may lead to instantaneous death. In Sabatier's case,* in

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* *Méd. Opérat.* t. ii. p. 400.

Boyn's case,* in both cases of Mounier,† no vestige of injury was found either about the brain or its membranes; and in one and all of these cases there was the same fatal omission,—neither the spine nor the heart was examined. And thus it is with O'Halloran of Limerick.

The perusal of such cases as these would really make it appear as if concussion of the brain had, at one time, been thought to be the only injury by which instantaneous death could be produced.

In all cases of sudden death from injury, there is no doubt that the parts to be examined are the upper portion of the spinal marrow and the heart. Neither is there any doubt that, if these parts are not examined, it cannot fairly be said, in such cases, that death was owing to simple concussion of the brain.

A man fell from a height of about forty feet, and died instantaneously. There was an extensive injury of the head; but this was not enough to account for instantaneous death. Further examination proved that there was also a dislocation of the atlas on to the occipital.

The following is a case even more illustrative. Death was not instantaneous; but death was, at first,—and this it is which makes the case so valuable,—thought to be dependent upon simple concussion of the brain. In the year 1843, a man was admitted into the Hôpital St. Antoine, having fallen from a great height on to the pavement. He was collapsed, and in a state of perfect insensibility. There was no paralysis, neither were there any spasms of the muscles. In this state he remained for some hours, and then died. The head was examined. Not a single trace of injury was detected in any of the cranial contents,—everything was perfectly healthy. The case was set down, by all those who had seen it during life and were present at the examination, as a case of death from concussion of the brain. It fortunately happened, however, that Dr. Deville, in going round the wards, heard the result of the examination, and thought it advisable that the spine should be looked to. He proceeded at once to the dead-house, laid open the spinal canal, and there found a most extensive extravasation of blood, completely filling up this canal in its whole length, and extending upwards, even beyond the point where the spinal marrow had been cut across, when the brain was taken out.‡

Had it not been for Dr. Deville, would not this case have been handed down to us, among the others, as one of death from simple concussion of the brain?

A boy fell from a great height, and was brought into St. George's Hospital with urgent symptoms of concussion, and various other severe injuries, of which he died in a few hours. The head was examined, and, save a little extravasated blood beneath the arachnoid on the surface of both hemispheres, with slight bruising of the brain in two places at its under surface, the brain and its membranes were perfectly healthy. And so, too, was the chest examined, and here was found a rupture of the muscular part of the septum of the ventricles of the heart right up to its serous covering, which alone prevented the blood from being poured into the pericardium. True it is that the pericardium in this case was not filled with blood; but a little more and it would have been so, and a complication, perhaps immediately fatal, superadded to the injury of the brain. And what makes this case still more interesting, as far as concerns our present subject, is, that there was not the slightest indication of any injury having occurred to the chest. No ribs were broken; and thus the rupture of the heart might easily have passed unnoticed, had it not been for the rule, now existing for several years at St. George's Hospital, of examining the various parts of the body in the post-mortem examinations.

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* *Thèses de Paris*, 1818, No. lv.

† *Thèses de Paris*, 1834, No. cxix. p. 19.

‡ *Mém. de la Soc. de Chirurg. de Paris*, t. iii. p. 180.

Other cases of a similar nature have fallen under my own notice; cases in which death was caused by rupture of the heart from injury, and in which death might have been ascribed to concussion of the brain, had not the heart been examined. It must be borne in mind, too, that instantaneous death, apparently caused by concussion of the brain, may in reality have been the result of fatty degeneration of the heart. Some years back, a man, middle-aged, and of spare habit, whilst endeavouring to lift a heavy clothes-basket on to his head, dropped down dead in Hyde Park. With such a history, the heart was first examined: there was no valvular disease, and no rupture of the heart; but there was extensive fatty degeneration of this organ. And now, supposing that the effort which cost this man his life had been made in endeavouring to save himself in a fall from a height, or to ward off a heavy blow from his head; and supposing too that, under such circumstances, the head only had been examined, and its contents found to be healthy, would not this case have been set down as one of instantaneous death from simple concussion of the brain?

As matters stand at present, then, it still remains to be demonstrated that concussion may prove fatal without leaving a trace of injury in the brain-substance.

This conclusion differs, I know, widely from the teaching of some of the greatest masters in surgery; but I can only say that there is not on record, as far as I have been able to ascertain, a single instance in which the evidence of instantaneous death from simple concussion of the brain will stand the test of anything approaching to a rigid scrutiny.

But of late years several pathologists, whose names stand pre-eminent in connection with cerebral affections, have taught that in fatal concussion appreciable lesions are to be found in the cerebral structures. True it is that these pathologists are not all exactly agreed as to the precise lesion: some—Chassaignac,* Nélaton, † Sanson ‡—taking merely the millet-seed-sized extravasations of blood disseminated in the substance of the brain, either on its surface or deep in its structure; others —Dr. Bright, § Blandin, ||—taking not only these specks of extravasation, but also the circumscribed patches of contusion. Still, these pathologists one and all agree in stating that some deviation from the healthy structure is to be found in concussion of the brain when it proves fatal. And M. Fano, one of the latest writers on this subject, comes to this conclusion: 'that the symptoms generally attributed to concussion are due, not to the concussion itself, but to contusion of the brain, or to extravasation of blood.'¶ And to this I may add, that in every case in which I have seen death occur shortly after, and in consequence of, an injury of the head, I have invariably found ample evidence of the damage done to the cranial contents. Setting aside the cases of large extravasations of blood upon the surface of the brain, the most speedy death has occurred in cases where specks of extravasated blood have been disseminated throughout the cerebral substance, or where blood has been extravasated into the structure of the pons Varolii.

Thus far, rapidly-fatal concussion only has been considered; but what appearance does the brain present when the injury has not been of so severe a nature, and where the patient has survived for some short time, or a few hours?

In such cases as these, where death has not taken place until a few hours after the accident, whether there be any actual lesion or not of the brain-substance, there is generally found intense congestion permeating the whole of the cerebral structures; so much so that, upon slicing the brain, innumerable blood-points may be seen everywhere thickly studding both the grey and the white substance. Such were the appearances in the case of Hœvelius, referred to by Morgagni.** This extensive congestion is also noticed by Dr. Bright,†† and by M. Fano,

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* *Des Plaies de Tête*, p. 104. † *Path. Chir.* t. ii. p. 575. ‡ Ibid.

§ *Med. Cases*, vol. ii. part i. 1831, p. 408.

|| *Gaz. des Hôp.* 1842, No. du 2 juin.

¶ *Mém. de la Soc. de Chir. de Paris*, t. iii. p. 199.

** *Lett.* 51, art. 10. †† Loc. cit.

in two of his experiments,* where the animals, after being thoroughly stunned for some few minutes, were allowed to come to again, and were then killed by other means within a minute or two after recovery. But the most strongly-marked case of this intense congestion is reported by M. Denonvilliers,† to whom the notes of the case were given by Dr. Bayard. And what makes this case still more interesting is, that many of the circumstances connected with it are strangely like those of the celebrated case of Littre. Arrested, and failing in his efforts to get away, the man dashed himself head-foremost against a wall, his hands being tied behind his back. He was picked up immediately afterwards perfectly insensible, and died three-quarters of an hour after the injury. As far as the brain itself is concerned, there was not even a speck of extravasation, either on its surface or in its substance, the consistence of which was perfectly natural. But the intense congestion of the vessels of the brain gave rise to a manifest alteration in the colour of its structures, its cut surfaces being thickly studded with the minutest blood-points, from whence oozed specks of fluid blood upon gentle pressure. And in this case, too, minute as was the examination in many respects, strangely enough there is no mention made as to any examination of the other parts of the body.

And now, as to the still slighter cases of concussion, where the patient is only stunned for a short time, and then recovers his senses completely. It is usually supposed that here, too, there is only some disturbance in the circulation of the brain, which being but slight, soon passes off.

As may be readily supposed, it happens but very rarely that there is any opportunity of examining the state of the brain in these slight cases of concussion. Sometimes, however, in cases where very slight concussion has existed, death does occur, not from the injury done to the brain, but from some other severe lesion. And in two cases of this kind which I have had an opportunity of examining, and in which symptoms of concussion, of the slightest nature, had altogether passed off within a very short time, I was surprised to find that the brain-substance itself was actually injured. In one case, in which, after a blow on the head, there had been mere giddiness for a few minutes, and then complete recovery, some patches of contusion were found at the base of the brain; marked by minute specks of blood closely clustered together, these patches were, in two or three places, of the size of a shilling, and extended, about a line in depth, into the structure of the brain: there were no disseminated specks of extravasated blood. In the other case, after a fall on the back of the head, the symptoms of concussion soon passed off, and the patient died of some other disease eight days after the accident. In the cavity of the arachnoid, and adhering to its parietal layer, were found thin layers of extravasated blood. The large veins on the surface of the brain were congested; the brain-structure itself was much darker than usual from congestion; and in the centrum ovale, close to the right side of the corpus callosum, and extending partly into it, was an extravasation of blood of the size of a nut. This clot still retained the greater part of its colouring matter, but the cerebral structure around it was neither discoloured nor softened.

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* Loc. cit., exper. 5th and 8th.

† *Compend. de Chir.* t. ii. p. 606.

Well-marked traces of injury were found after death in the brain itself in both these cases. May not such lesions also exist in many so-called slight cases of concussion of the brain which recover? My own impression is, that such appearances exist more frequently than is generally supposed.

Many other morbid appearances have been given to concussion of the brain; but to these I should not allude, were it not that I find them mentioned in some recently-published text-books on surgery. For instance, among the after-death appearances in concussion of the brain, separation of the dura mater from the inner surface of the cranium, when the blow on the head was severe, is said to be a very common condition. As well might we say that in concussion of the brain the bones of the skull are often broken.

Concussion of the brain may be produced in different ways; either directly, from the force being applied to the skull itself; or indirectly, from the shock being transmitted through some other part of the body. What actually happens to the brain in concussion, M. Gama has ingeniously endeavoured to demonstrate, by means of a glass matrass filled with a solution of isinglass, approaching as nearly as possible to the consistence of the brain, in which he arranged several threads. And from what he observed in these experiments, M. Gama concludes that a blow bearing upon any part of the vault of the skull, in such a manner as to have its opposite point also in the vault, will lead to a separation of the brain from the skull at these two points. But if the blow bear directly upon the vertex, the separation of the brain will only take place at the point struck; and towards the base of the skull, all that will occur, on account of the flatness and extended surface of this part, will be disseminated 'contre-coup.' Lastly, in a shock transmitted through the base of the skull, the motion being distributed from within outwards, there will be no separation of the brain at any point of the skull; thus pressed outwards, the cerebral mass, on the contrary, here becomes applied all the more forcibly against the osseous box.*

Such are M. Gama's conclusions. The experiment, it is true, is only a rough one; but notwithstanding this, some notion may, I think, be gathered from it, as to what takes place when the brain is shaken.

It is not many years since that surgeons were at great pains to point out the different symptoms which, it was thought, served clearly to distinguish a case of concussion from one of compression. Has further experience proved the correctness of the distinctive characters about which there was at one time so much controversy? I think not. It must be admitted that there is no one symptom, or combination of symptoms, which will enable us to determine positively between concussion and the slighter cases of compression.

And this it is which renders an accurate diagnosis so very difficult, if not altogether impossible, in many cases of injury of the head; the difficulty itself being, no doubt, dependent in many cases upon the complex nature of the injury.

Cases of concussion of the brain are now commonly divided into three broad classes. All classifications of this nature must necessarily be vague and arbitrary; but, nevertheless, some classification of these cases will be found useful both as regards the symptoms and the treatment. In the slighter cases, the effects of the concussion are momentary—loss of sensibility and of muscular power, interference with the circulation; these symptoms soon pass off. The patient comes to again, and proceeds about his business as if nothing had happened, retaining often no knowledge whatever of the accident. In the severest forms of concussion, the patient dropping instantaneously lies senseless and motionless; scarcely breathing, and with no pulse at the wrist. Little or no reaction takes place; and the patient expires within a few minutes or lingers on for a few hours.

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* *Des Plaies de Tête*, 2^{e} édit. p. 101.

But cases of concussion holding the mean between these two extremes are to us, as practical surgeons, of the greatest interest. At first perfectly insensible, the patient lies motionless and all but pulseless; with a countenance marked by extreme pallor, and a skin quite cold. The breathing, although feeble, is in the great majority of cases performed easily and naturally. The pupils vary very much—contracted, dilated; or one may be contracted, and the other dilated. The urine and the fæces are sometimes voided involuntarily. And in this state the patient may remain for a longer or a shorter period, after which he begins to rally.

No longer altogether insensible, he may be roused by loud calling; pinch the leg, and it will be withdrawn with an expression of peevishness about the countenance; the pulse becomes less frequent and more distinct; colour returns to the face, and the skin gradually regains some warmth. And among the earliest signs of amendment must be mentioned vomiting, which is to be looked upon as a good sign; and when it supervenes, sometimes appears to hasten the recovery.

And thus matters may go on for a few hours, or for a few days; but as soon as the patient is so far restored as to be able to make any complaint, headache, of a more or less severe character, is almost always found to be present. This pain in the head may exist for a longer or a shorter period, and then pass off; or it may soon be followed by other symptoms, indicative of intra-cranial inflammation.

Such are the symptoms attributed by most surgeons to concussion of the brain, when it has been of a somewhat severe character. But at the bed-side of a patient labouring under such a train of symptoms, after an injury of the head, can we undertake to say that he is suffering from concussion of the brain only? Nay more, let the symptoms gradually pass off, and let the patient be so far restored as to be able within forty-eight hours to answer questions put to him; let him, in fact, give ample proof of returning intelligence; could we venture, in such a case, upon stating that the case was one of simple concussion? that the prolonged symptoms were not, in a great measure at any rate, due to an extravasation of blood within the membranes, to which the brain had become accustomed?

We may think that the case was one of pure concussion; and at the death of the patient, what do we find? Perhaps, an extensive extravasation of blood within the arachnoid.

An elderly woman having been knocked down and run over by a cab, was admitted into St. George's Hospital, with a severe injury of one of the hands and concussion of the brain; the symptoms of which, however, soon passed off, and she was up and about the ward in a few days. Ultimately, erysipelas made its appearance on the hand, and she died, after having been in the hospital about two months. From first to last the head-symptoms had been attributed solely to concussion of the brain; and yet, at the after-death examination, extensive layers of blood, membrane-like, were found in the cavity of the arachnoid on both sides.

A man aged fifty-three, having fallen down stairs, was admitted into St. George's Hospital, with what was thought to be simply severe concussion of the brain. From this he gradually recovered, and was in due course of time allowed to get up and go about the ward. He died, however, of an attack of erysipelas, two months after the accident. The brain-substance was perfectly healthy, but within the cavity of the arachnoid, on both sides, were the remains of an extensive extravasation of blood, membrane-like, and adhering to the parietal layer of the serous membrane.

I might mention several other cases in which extravasations of blood were found in the cavity of the arachnoid—cases in which the symptoms of concussion had even been altogether transient, and in which death had been brought about by some other cause. Indeed, I cannot help thinking, from all I have seen, that many of the so-called cases of concussion, especially the severe cases in which recovery has taken place at a more or less remote period, have, in truth, been cases of extravasations of blood within the membranes.

There is also many a case recorded by eminent surgeons, and as a matter of course quoted over and over again, in which partial paralysis and loss of memory are said to have taken place after, and to have been due to, concussion of the brain. But here, too, it is much more probable that effects such as these were due not to concussion only, but to some extravasation of blood, or to some local injury done to the brain-substance.

As we have some clearly-marked periods in the symptoms of concussion, so too must we adapt our treatment to these various periods.

In the first period, that of depression, the safest practice is certainly to do as little as possible—to avoid all interference either in the way of blood-letting, on the one hand, or in that of stimulating on the other. Bleeding to any extent, in such a state of depression, may be the cause of most serious mischief, even of death itself. And with regard to stimulants recourse must be had to them as little as possible; for we cannot be sure that we may not be dealing with a case of extravasation of blood, or of bruised brain; and a period of depression, under such circumstances, would be the safeguard of the patient. Cases of concussion absolutely requiring stimulants are very rarely met with in practice; and even when of a very severe form, all that is necessary in the great majority of cases is, to apply warmth to the surface, and carefully to watch the case; but if it should so happen that the patient is manifestly in danger of sinking from depression of the circulation, then, no doubt, stimulants or cordials must be resorted to.

As is the state of depression, so too will be the state of reaction: slight depression will be followed by slight reaction; extreme depression by extreme reaction, which will be all the greater if stimulants are used.

And in the stage of reaction, so long as this reaction keeps within due bounds, here again it is better to abstain from all active interference; taking care, however, to exclude all possible sources of excitement; to keep the head and the shoulders well raised, and evaporating lotions constantly applied to the head, which in bad cases must be shaved. Precautionary measures such as these, with a mercurial and saline purge occasionally, and great attention to diet, with perfect rest, will, in a large number of cases of concussion carry the patient through this period.

When the concussion has been of a somewhat severe character, there is generally no difficulty in getting the patient to submit to the necessary regimen—his own feelings tell him, in fact, that it is absolutely necessary; but in the slighter cases, where all the symptoms soon pass off, feeling as well as he does for the time being, the patient not unfrequently resists all attempts at treatment, and then, within a few days, is laid low, with mischief of a very severe and dangerous nature—so dangerous, indeed, that notwithstanding all care, a few days more bring his life to a close.

In the cases of concussion which die, from some other cause, shortly after an injury, and in which no extravasation of blood or actual injury to the brain-substance is found, there is, it must be recollected, intense congestion of the cerebral vessels, which, in some cases, is so intense as to give a manifestly darker hue to the different substances of the brain. The cases revealing these early appearances are of the utmost value practically; they at once plainly point to the mischief which is likely to arise, and at once give the key to the treatment.

The great danger lies in the tendency which this congestion has of leading to inflammation, and hence the reason why the case is to be so narrowly watched; hence the reason why the state of the pulse and all other symptoms are to be so carefully inquired into, and even the slightest appearances of mischief, as far as possible, guarded against. But intra-cranial inflammation, taken as a whole, will form the subject of another section.

I cannot, however, dismiss this subject of concussion of the brain without again referring to a point which I consider of the utmost importance in all cases of injuries of the head, of whatever kind. In dealing with scalp-wounds and with fractures of the skull, I pointed out how necessary it was to take into consideration the state of the various viscera, and especially of the kidneys. To scalp-wounds and to fractures must now be added concussion of the brain; the diagnosis, the prognosis, and the treatment of which must be greatly influenced by the condition of the viscera.

Contusion of the Brain.

In dealing with the subject of concussion of the brain, allusion was incidentally made to the bruised appearances often observed about the cerebral substance, where the case had been set down as one of simple concussion.

It is this bruised appearance or contusion of the brain-substance which is now to be brought more directly under notice.

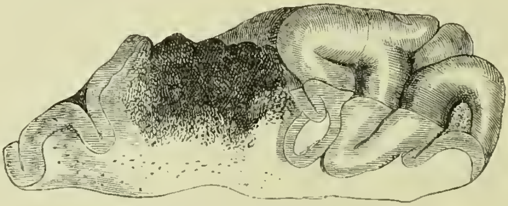
Bruising of the brain-substance presents itself under two different aspects; either spots of extravasated blood are clustered together in well-marked circumscribed patches, or these spots are disseminated throughout various parts of the cerebral mass at the same time. Hence a circumscribed and a diffused form of contusion of the brain.

The former, the circumscribed contusion, much the more common of the two, will be treated of first.

As in other organs, so in the brain, there may be different degrees of contusion. In the slighter cases, the bruised part, of a dark-purplish colour, is found upon close examination to be studded with minute specks of extravasated blood, not bigger than pin-points, thickly clustered together; the discoloration gradually lessening from the centre to the circumference, as the specks of blood become more and more scattered.

The gray substance alone is affected. Under a gentle stream of water, the patch, if examined within a short time after the injury, retains both its discoloration and its consistence.

Fig. 55.



Contusion of the Brain.

In the more severe cases, the central parts of the bruised portion, thoroughly infiltrated with blood, are of a uniform, dark-purplish colour, which extends some distance both into the gray and the white substances; imbedded in this part are little clots of blood of the size of peas, and around the circumference and in the deeper parts are specks of extravasation scattered more and more widely until they gradually disappear. The brain-substance—torn, broken up, and shreddy—readily gives way under a gentle stream of water, which, gradually loosening the clots of blood, carries them away, leaving little pits with irregular and shaggy margins, and thickly studded throughout with pin-point extravasations.

Such are the appearances at an early period after the injury. A few days later, and the bruised part, with its depressed shaggy surface, and sharp irregular borders, looks like an ulcer, and by some surgeons has, in fact, been described as the traumatic ulcer of the brain. At this period, too, the brain-tissue to some distance around the bruise may be of a yellowish colour, and each little speck of extravasation may have its own circle of yellow surrounding it.

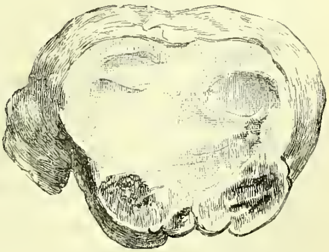
Slight contusion of the brain may sometimes be found alone; but, for the most part, the various degrees which have just been described coexist in the same brain.

As to the membranes of the brain, in the slighter cases of contusion, the meshes of the pia mater only are more or less filled with small clots of extravasated blood; in the severer cases, both the investing arachnoid and the pia mater are generally torn, and blood is more or less extensively extravasated in the cavity of the arachnoid, as well as in the meshes of the pia mater. Out of sixty-nine cases of more or less severe contusion of the brain, independent of compound fractures, I found blood extravasated into the cavity of the arachnoid in no less than in fifty-two cases. And in thirty-one out of these fifty-two cases, the extravasation was very extensive; so much so, indeed, in several instances, that the quantity is marked thus in the notes of the case: 'within the arachnoid large quantities of blood spread out and capping the brain.' In eleven cases, no blood was found in the cavity of the arachnoid; but in all these eleven cases, blood was found in the meshes of the pia mater, extending some distance beyond the actual seat of the brain-injury, and in six of them the extravasation was widespread. In the remaining six cases, no blood was found in the arachnoid, and none in the pia mater, except at the actual seat of the injury, and this only in very minute quantities.

Bruising of the brain may occur in every part of this organ; but all parts of the cerebral mass are not equally subject to this form of injury. Some parts of the brain are so frequently bruised that cases of this kind are seldom wanting in the dead-houses of our large hospitals; and other parts, again, are so very rarely injured, that one or two cases only may be met with in a long series of years.

It is but very, very rarely, for instance, that an opportunity occurs of seeing the *medulla oblongata* or the *crura* thus bruised. There is, however, a preparation in the Museum of St. George's Hospital in which several small spots of extravasated blood may be seen scattered deep in the structure of the upper part of the medulla oblongata, as well as in that of the crura of the cerebrum and cerebellum. In this case, too, there were also spots of extravasated blood deep in the pons Varolii; some of these spots were of the size of pin-points, and others, again, as large as a small split-pea. No other part of the cerebral mass was bruised or lacerated; but there was an extensive extravasation of blood over the whole of the right hemisphere, and the cerebellum was

FIG. 56.



Extravasation of Blood in Pons Varolii.

bathed in blood. The bones of the skull were not in the least injured.

Of the *pons Varolii* only four other cases of contusion have been met with at St. George's Hospital within the space of sixteen years. And the cases of this kind on record are also but few in number.

In a case mentioned by M. Boinet,* the centre of the pons Varolii was bruised, and this was the only injury existing about the brain-substance. And in another case by M. Fano,† the structure of the pons Varolii was studded with several small extravasations of blood about the size of a split-pea; the anterior lobes of the brain were extensively bruised and torn, but the skull was not broken.

One point especially must be borne in mind in connection with these traumatic extravasations both in the medulla and in the pons. The surface of these structures may be perfectly healthy, and yet well-marked spots of extravasation may exist deep in the substance, and that, too, even when there has been no bruising of any other part of the cerebral mass. Contusions such as these may then, it is evident, easily escape notice, unless very carefully sought after.

In the *cerebellum*, bruising and laceration occur more frequently than in the structures which have just been examined; and in this organ these injuries are, for the most part, to be found at its under surface. The spots of ecchymosis are generally small and superficially situated, and confined, moreover, to one lobe at a time. Sometimes, however, extravasations take place in the deeper parts, and then there may be either one largish single spot, as in a preparation in the Museum of St. George's Hospital, in which an extravasation of the size of a filbert is imbedded deep in the structure; or there may be, as in Blandin's case,‡ a large number of minute spots scattered in the substance of this organ. In the twelve cases of bruising and laceration of the cerebellum, notes of which I have by me, other parts of the brain were at the same time extensively bruised, and the skull was broken. The nature of the accident was not always very severe, and this must be borne in mind. In several instances I found that the cerebellum was thus injured by the patient having fallen in the street while drunk.

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* *Arch. Gén de Méd.* 1857, p. 50.

† *Rech. sur la Cont. du Cerv.* obs. xii. p. 25.

‡ *Gaz. des Hôpitaux,* juin 2, 1842.

In the *cerebrum* itself it will be found that even here some parts of this organ are much more commonly affected than others. As in the cerebellum, so in the cerebrum, the under part is very much more frequently bruised than any other. Sometimes limited to a few patches of contusion, the injury much more commonly extends over the whole surface of a lobe, and oftentimes of two lobes at once. Both the gray and the white substance may be extensively involved; and, in depth, I have known the whole structure to be so broken up and destroyed that the lateral ventricle has been laid open. A man fell from a height of about eight feet, the result of which was extensive bruising and laceration of the under surface of both anterior lobes; freely laying open, on the right side, the lateral ventricle, into which the finger was readily passed. And, in another case, a man fell from a tree a distance of fourteen feet, and so injured the under surface of the anterior lobe on the right side that the lateral ventricle was here freely laid open.

But in the cerebrum, too, the deeper parts may every now and then be found bruised; and the bruise, thus deeply situated, may either exist alone, or it may coexist with an injury of the surface, although independent, and far away from it. And every part of the cerebrum may be thus injured; and being, perchance, very limited, the injury may here also easily escape notice. Thus, in one case, the septum lucidum was lacerated in nearly its whole length; it appeared to be bruised, and had several spots of ecchymosis in various parts of the remaining portion of the septum, and in the fornix at the back part. No other laceration was detected in any other part of the cerebral mass; but several patches of extravasated blood existed in the cavity of the arachnoid, and in the meshes of the pia mater. In another case, a minute extravasation of blood was found in the edge of the fornix, another on its under surface, and several specks also on the surface of the thalamus; the only other traces of injury were patches of blood in the sub-arachnoid tissue, corresponding to the posterior lobes of the cerebrum, and to the posterior part of the cerebellum. In a third case, the extravasation of blood in the brain was of the size of a nut in the right centrum ovale, close to the side of the corpus callosum; no other laceration could be detected in any other part of the cerebral mass, but several thin layers of blood were found extravasated in the cavity of the arachnoid. In a fourth case the corpus callosum and the velum interpositum were slightly bruised, in connection with superficial bruising of the surface of the brain; and in a fifth case, several minute specks of extravasated blood were discovered in the fornix and septum lucidum, in connection with other and severe bruises of various parts of the brain. And in connection with this subject it may be mentioned that a laceration of the floor of the lateral ventricle, even when very, very slight, may give rise to an extensive extravasation of blood into this cavity, should it so happen that the injury corresponds to the situation of one of the large veins in this region. In a preparation in the Museum of St. George's Hospital, there is a slight laceration of the septum lucidum, as well as of the floor of the left lateral ventricle, where a large vein was laid open, and the ventricle was full of blood.

Thus much as to circumscribed contusion of the brain. In the general or diffused contusion of this organ, the spots of extravasated blood, instead of being clustered together in one part, are disseminated throughout the brain, on the surface as well as in the deeper parts, or it may be in the deeper parts only.

Circumscribed contusion of the brain we already know to be of very frequent occurrence. Diffused contusion of this organ, we shall find, on the other hand, is but very rarely met with. Circumscribed contusion is for the most part easily detected, and at once clearly recognised. Diffused contusion is sometimes difficult of detection, and, without careful examination, may readily pass unnoticed.

Diffused contusion of the brain is characterised by specks of extravasated blood disseminated throughout the brain-substance. These minute extravasations vary from the size of the smallest pin-points to that of a split-pea. In the latter form, the extravasation could hardly escape detection; but in the former, the minute specks might, in slicing the brain, be easily mistaken for the cut surface of the cerebral vessels. A little care, however, will enable us to distinguish between the two. In the case of cut vessels, the specks can be easily wiped away, and then, by gently squeezing the brain, other specks of blood may be made to appear. The miliary extravasations cannot thus be wiped away; but, picked out with the point of a knife, they leave little holes, in which the concrete drop of blood was imbedded. The brain-substance around these minute holes may still retain its natural colour; or, some days after the accident, it may be of a yellowish colour, such as is so frequently noticed under similar circumstances in bruises of other parts. Thus, in Blandin's case, already alluded to, which terminated fatally some eight or ten days after the injury, each little spot of extravasated blood was found encircled by cerebral substance of a yellowish tinge, varying from a violet colour to a greenish yellow.

The specks of extravasated blood characterising diffused contusion of the brain may, in any case, be numerous, or they may be few; sometimes so few, indeed, that one speck here and there is all that can be found. And this points out at once what extreme care must sometimes be required in examining cases of this kind; and it also points out how readily a lesion of this delicate nature may escape notice in a rough examination—such, for instance, as used formerly to be carried on in our dead-houses.

One of the best-marked cases of diffused contusion is that described by M. Chassaignac in the *Mém. de la Soc. de Chir. de Paris*, vol. iii. p. 208. Another equally well-marked case is that of Blandin above alluded to. In both these cases, the miliary extravasations were very numerous and widely scattered; but in a case which occurred at St. George's Hospital in the year 1854, the spots, although well marked, were very few. In this case, three very small spots of extravasated blood were found in the substance of the anterior lobe of the left hemisphere; another small spot in the fornix, and another in the right lobe of the cerebellum. And these were all: some minute extravasations existed also in the cavity of the arachnoid, and in the meshes of the pia mater; but there was no fracture of the skull.

These minute traumatic extravasations of blood scattered throughout the brain-substance have of late years been looked upon, as I have already said, by some surgeons of eminence, as especially belonging to concussion of the brain; but such appearances cannot properly be assigned to concussion. Miliary extravasations of blood, whether clustered together in one patch, or disseminated in various parts, belong, one and all, to contusion of the brain. The morbid appearances, although apparently so dissimilar, are essentially of the same character. The contusion, limited in one instance, is general in the other.

Bruising of the brain-substance may take place at the spot where the skull was struck; or the bruise may be in a part of the brain far away from the original seat of the injury. The one, then, is a direct contusion, the other a contusion by contre-coup, of the brain-substance.

And as an illustration of what takes place in contusion of the brain, reference may be made to experiments such as M. Gama's, in which may be seen the effects produced upon the spot where the blow bears directly, as well as the effects which occur in the parts diametrically opposite.*

Contusion of the brain is, however, rarely limited to the region where the blow was struck, except in cases where the bone has been driven down. In fissure of the skull it happens much more frequently that the bruised part of the brain is far away, and directly opposite to the seat of the blow. In severe injuries, both kinds of contusion, direct and by contre-coup, are sometimes found in the same brain.

Bruising of the brain occurs, then, in some parts of this organ much more frequently than it does in others. The upper part of the brain is seldom bruised. Out of thirty-six cases of bruised brain accompanying fractures extending from various parts of the vault into the base of the skull, the upper surface of the hemispheres was bruised in five cases only. The base of the brain is the part most frequently injured; but even here the various regions differ widely in this respect. The posterior lobes are rarely injured, the anterior ones very frequently, and the middle lobes the most frequently of all. Out of the thirty-six cases just alluded to, the posterior lobes were bruised in four instances only, the anterior lobes in eighteen, and the middle lobes in no less than twenty-five. In twelve of these cases, the anterior and the middle lobes were bruised at one and the same time, the injury having been most severe.

And now, bearing in mind what was stated as to the frequency of the fractures of the various regions of the base of the skull, the middle part of the base of the brain, like the middle fossa of the skull, will be found to be the most frequently injured.

The analysis given by M. Fano as to the frequency of the contusion of the various parts of the brain differs from that which I have just mentioned. M. Fano* found the anterior lobes more frequently bruised than any other part of the brain; but then the number of cases thus analysed was very small—only eight. Had M. Fano's numbers been larger the results would, I think, have been pretty much the same in both analyses.

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* *Des Plaies de Tête,* 2^e édit. p. 101.

Why is it that the middle and the anterior lobes are so much more frequently bruised than the posterior ones? A glance at the anatomical relations of these various parts of the base of the brain affords, to a certain extent, a satisfactory explanation. The posterior lobes lie upon a soft cushion, the tentorium cerebelli; but the anterior and middle lobes are in contact with irregular and angular projections of bone, which, although rounded off to a certain extent, and smoothed down by the dura mater, are still both sharp and numerous.

This subject has been made one of importance by M. Fano,† who after carefully pointing out the various pieces of sharp bone in these parts, expresses great surprise that no allusion should ever have been made to them in connection with contusion of the brain by contre-coup. The following, however, are Sir Benjamin Brodie's own words, written some thirty years ago now: 'The great irregularities which exist on the inner surface of the basis of the cranium sufficiently explain wherefore the inferior is more liable to be ruptured than the superior surface of the brain.'‡ And nothing could be more explicit.

Are there any means of recognising the cases in which the brain has been thus bruised and lacerated?

Dupuytren,§ to whom we owe much of what is known of contusion of the brain, was decidedly of opinion that we had no means of recognising this injury. This celebrated surgeon distinctly taught that contusion of the brain does not reveal itself by any symptoms until a few days after the accident; that is, until the period—four or five days after the injury—at which inflammatory symptoms begin to show themselves.

And such, too, was the opinion first entertained by Sanson. 'It is not until after four or five days that the signs of contusion become manifest; and then these signs are similar to those of inflammation of the brain.'* But in after-years, laying aside this opinion altogether, Sanson professed that contusion of the brain has its own characteristic signs, which, appearing at the very time of the accident, clearly reveal the nature of the injury.† And the symptoms by which Sanson thought that he could thus at once recognise contusion of the brain are, in the severer cases, tonic spasms of the limbs; intense restlessness, with constant rolling and tossing about in bed; unconsciousness, more or less complete; drowsiness, without any stertorous breathing. And in the slighter cases, simply contraction of one pupil, or of one eyelid; spasmodic movements about some one muscle or another of the face or lips, giving rise to a difficulty of pronunciation.

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* *Thèse sur la Cont. du Cerv.* p. 44.

† Loc. cit. p. 44.

‡ *Med.-Chir. Trans.* xiv. p. 334.

§ *Clin. Chir.* t. ii. p. 490.

Such was Sanson's teaching in his latter years; and such, for the most part, is the teaching of the present school of French surgery, wherein it is broadly and distinctly laid down that, as a general rule, contusion of the brain does at the very outset give rise to a train of symptoms by which the injury may be recognised, if the various symptoms be only weighed with due care.

But after careful and patient watching of many a case of severe injury of the head, I must confess that I do not think we are really in a position thus clearly to recognise a case of contused brain.

There is no doubt that cases of contusion of the brain are frequently met with, in which tonic spasms of the muscles and extreme restlessness, with constant tossing and rolling about, are the principal symptoms; but there is no doubt also, that as frequently, if not more frequently, cases of severe contusion of the brain are met with, in which the symptoms either never make their appearance until some days after the accident, or are altogether wanting.

I have, I think, fairly tested Sanson's doctrine, both in the wards and in the dead-house; and, from all I have seen, I have been led to conclude, that contusion of the brain does not give rise to any symptoms immediately after the injury—that it has, in fact, no characteristic signs of its own.

M. Fano, to whose valuable thesis I have already referred, has come to the same conclusion. And in this thesis‡ will be found an able analysis of the memoir which M. Boinet* wrote for the express purpose of maintaining and proving the correctness of Sanson's views. In summing up the cases brought forward in this memoir, M. Fano proves that seven only out of the nineteen were really of any value for M. Boinet's purpose. In these seven cases, the so-called characteristic symptoms coexisted with contusion of the brain; but then, in these seven cases, there were also, about the head, other lesions of a serious nature, which may perhaps have had just as much to do with the symptoms as the contusion of the brain.

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* *Dict. de Méd. et de Chir. Prat.* t. viii. p. 452.

† Boinet, *Arch. Gén. de Méd.* mai 1837, p. 39.

‡ Op. cit. p. 23.

Why should not a thin stratum of blood widely spread over the brain—why should not laceration of the investing membranes of the brain, have something to do with the tonic spasm and the restlessness? In severe bruising of the brain, these lesions are very common; so common, that, as I have already mentioned, out of sixty-nine cases of this kind, blood was found extravasated in no less than in sixty-three. And, as a possible cause of the symptoms, there is also the intense congestion which, it is known, takes place in the brain-substance almost immediately after it has been bruised.

But why is it that such symptoms exist in some injuries of this kind, and not in others? To this the only answer that can be given is that this is one of those questions which cannot be fairly met in the present state of our knowledge.

There are, then, no characteristic signs by which contusion of the brain can be clearly recognised; but, nevertheless, it may be predicted that the brain has been bruised, whenever the symptoms are severe after an injury of the head. At least, certain it is, that in severe injuries of this kind, and especially after diffused blows—the most common form of accident in civil hospitals—certain it is that in the vast majority of these cases the brain will be found bruised. Nay, more; if we bear in mind which parts of the brain are the most frequently thus injured, we may even go so far as to say that it is the under surface of the middle or anterior lobes which is bruised.

Contusion of the brain must be considered as a most dangerous injury; but is it always fatal?

One sees patients recover after an injury of the head, in whom it was more than probable, from the nature of the accident and the severity of the symptoms, that the brain was bruised; but of this, unless in very rare circumstances, no positive evidence can be obtained.

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* Loc. cit.

When recovery does take place, the contusion is repaired in the same manner as apoplectic hæmorrhage into the brain. In the slighter cases, all traces of the contusion may have passed away, if death occurs independently of, and some time after, the accident; or the only trace left may be a hardened cicatrix, with, perhaps, some colouring matter in the centre. But clearer evidences of a former contusion of the brain are occasionally met with; and here, the appearances, as might have been expected, are precisely similar to those observed in old apoplectic effusions. If on the surface of the brain, the portion which had been bruised may present some of the well-known appearances so accurately described by Rokitansky,* in his peripheral form of apoplexy. Of this Mr. Henry Lee's case affords a well-marked illustration.†

Since the above was published, I have had an opportunity of examining the brain of a man who, twenty years before his death, had been under my care for a very severe injury of the head. The convolutions of the anterior part of both hemispheres of the brain were extensively excavated, and here the arachnoid and pia mater were carried evenly over both depressions, so that a space was enclosed beneath them, which was filled by loose areolar tissue and serum. In the right hemisphere, the mouth of the excavation was nearly circular, about an inch and a half in diameter, and so placed, that the inferior margin lay close to the base of the brain, whilst the inner one was close to the median fissure. The depth of the excavation was about an inch, and the convolutions around its edge were natural. The cavity commenced for the most part abruptly, but one or two convolutions could be traced in a stunted condition down the walls, which had an even surface, and were loosely coated with areolar tissue. In the corresponding part of the left hemisphere, there was also an excavation, similar in all respects, save that it was only about half the size of that in the right hemisphere. The cerebral tissue, in the neighbourhood of these cavities, and forming their walls, had a perfectly healthy appearance. There were no remains of blood extravasated in the cavity of the arachnoid; the other parts of the brain were perfectly healthy, and so, too, was the brain-case; no traces of fracture; no sign of injury to the bones. The patient died of aneurism of the subclavian artery, at the age of forty-eight, but twenty years before his death he had been admitted into St. George's Hospital, when I was house-surgeon, with several other men, all of whom had fallen a great height in consequence of the giving way of some scaffolding. At the time of his admission, he was suffering from several severe injuries; and especially of the head, marked by the symptoms of so-called concussion of the brain, but there was no sign of fracture of any part of the skull. For several days, he struggled between life and death, in a state of perfect unconsciousness, followed by a violent delirium, which ultimately, however, subsided, and in a few weeks he was so far well, that he was able to leave the hospital. After a while, he resumed his occupation, that of a house decorator, and for years he worked for one of the best firms in London, and was known as one of their ablest workmen. His intellect was as clear as it had ever been, and when I accidentally met him, from time to time, he always said that he did not suffer more from headaches than other people.

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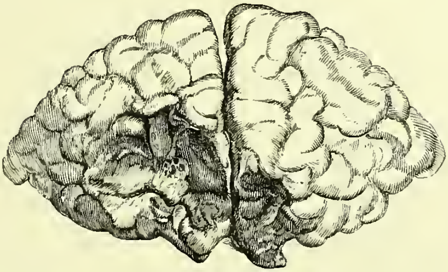
* *Path. Anat.* vol. iii. p. 394.

† Guthrie, *Inj. of the Head,* p. 68.

The specimen is in the Museum of St. George's Hospital, and from it the annexed woodcut was taken.

Fig. 57.



Depression of Brain.

In dealing with concussion of the brain, I have already remarked that it is more than probable that some of the cases so often quoted as instances of slight paralysis, or of loss of memory after concussion, were in reality cases in which the brain had been bruised. Of this I think that there can be no longer any doubt.

That which is most to be feared, when the brain has been bruised, is inflammation of the surrounding substance; and this it is which must be guarded against as much as possible. The great tendency in injuries of this kind is, that the brain and its membranes should become inflamed; and as this inflammation is apt to creep on most insidiously, every injury of the head in which the symptoms have been marked ought to be most carefully watched, and treated accordingly. Our watching ought to be carried on for days, for oftentimes the symptoms of traumatic inflammation suddenly show themselves, and without any manifest cause, when all was apparently going on well. The fourth or fifth day was stated by Dupuytren and by Sanson to be the period at which the febrile symptoms were likely to make their appearance. This, then, is the period when we ought to be most watchful for even the slightest sign of inflammation of the brain and its membranes; but of this I intend to treat at length in another section.

PROTRUSION OF THE BRAIN-SUBSTANCE.

Protrusion of the brain may be the immediate consequence of, or it may come on some time after, the accident.

Contused and lacerated portions of brain-substance may be driven through a fracture of any part of the skull; such protrusions almost always, however, occur in some part of the vault, in connection with a compound fracture and laceration of the cerebral membranes. And however dangerous such an injury may be, the records of surgery contain a large number of cases in which, after the escape of more or less cerebral matter, the patient has recovered, and that without any apparent detriment, either physical or intellectual. Opinions, however, differ as to the chances of recovery in wounds of the brain in different regions of the vault of the skull. On the one hand, Sir Benjamin Brodie* states that he had not been able to discover, among all the works which he had consulted, a single instance of recovery from a wound of the posterior lobes of the cerebrum; and in the great majority of cases in which a cure had taken place, the injury was confined to the frontal bone, and that part of the brain which is covered and defended by it. On the other hand, Mr. Guthrie's† experience led him to believe that an injury of apparently equal extent is more dangerous on the forehead than on the side or middle of the head, and much less so on the back than on the side.

But it occasionally, although very rarely, happens that brain-substance is forced through a fracture of the base of the skull, in direct communication with the ear or with the nose, or it might be with the pharynx. In such cases, the injury done to the brain-case and its contents must, as a matter of course, be most severe, and with very rare exceptions, necessarily almost always fatal.

Of brain-matter forced through the meatus externus, I saw a case at St. George's Hospital in October 1856. The accident was caused by a fall head-foremost from a great height; and with profuse bleeding from the left ear were mixed minute portions of brain-substance, and two or three larger pieces, as big as peas, of the white substance of the brain were lying in the meatus externus. Two cases of the same kind are on record; one in the *Journ. de Méd. et de Chir.*, 1779, vol. lii. p. 454; and the other in the *Annales de Chir.*, 1843, vol. viii. p. 229.

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* *Med.-Chir. Trans.* xiv. 421.

† *Injuries of the Head*, p. 2.

Of brain-matter forced through the nostrils, a case is recorded in the *Compend. de Chir.*, vol. ii. p. 595; and another in the *Bull. de la Soc. Anat. de Paris*, 1837, p. 228.

Injuries such as these are, I said, necessarily almost always fatal. Occasionally, however, recovery does take place. One such case I recollect seeing at St. Bartholomew's Hospital, under the care of Mr. Stanley. There had been a fall from a height of twenty feet; and, with some clots of blood, a portion of the brain of the size of a hazel-nut escaped through the right nostril. The injury was followed by severe inflammatory symptoms; but notwithstanding all this, the man, aged forty, was discharged from the hospital, cured, eighteen weeks afterwards. The case is published in the *Medical Gazette*.* And another case of recovery after an equally severe injury has lately been recorded in the *Amer. Journ. of Med. Sc.* April 1859, p. 354. In this case, the patient, aged thirty, plumped from a great height on to the crown of his head; there was copious bleeding from the right ear, and with it a small quantity of brain-matter. On the following day, a fluid of watery character was flowing from the ear; and in the meatus were several particles which, carefully examined, proved to be true brain-matter. The man returned to his duty five weeks after the accident.

I have never seen a portion of the brain forced into the pharynx, but I have found the contents of the pharynx within the skull, into which they had passed through a widely-separated fracture at the base.

Thus far those cases only have been considered in which protrusion of the brain occurs at the time of the accident. In all these cases it is the broken-up brain-matter which is driven out of the skull; about this there is no doubt.

But protrusions at times occur a longer or a shorter period after the accident, which have been described, more especially by English surgeons, under the term of hernia cerebri; and under this general head have been included protrusions of divers natures, and some even having nothing of brain-matter in them.

Some protrusions are said to have arisen simply from blood extravasated on the outer surface of the dura mater. Described as *tumeurs hématiques* by M. Velpeau, such protrusions have nothing to do with the brain-substance; the dura mater is not even broken through. An outgrowth of this nature might present all the appearances of one form, at any rate, of hernia cerebri; and most difficult would it be, during life, to decide as to the precise connections of the tumour. But cases such as these must be very rare.

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* New ser. vol. iii. 1846, p. 77.

In hernia cerebri—such, I mean, as it is described by English surgeons—the protruded substance appears to have varied somewhat in its nature; but, whatever may have been the actual appearance of the tumour itself, the dura mater was at any rate torn through, and the protruded substance was more or less intimately connected with the brain. In some cases, the protrusion is described as having been chiefly composed of blood extravasated under the pia mater, between it and the surface of the brain, or in its most superficial parts. In other cases, the appearance of the protruded mass was that of true brain-substance, looking exactly like the structure of the brain, with which it was continuous. And in other cases, again, the tumour is represented as an over-abundant granulation from the brain, the injury of which it was destined to repair. Indeed, some surgeons believe that this is the only form in which hernia cerebri shows itself: not then a protrusion of brain-matter; not a hernia cerebri; but simply a growth from its over-luxuriant granulation.

Personally, I have had but very few opportunities of examining the substance driven out of the skull in hernia cerebri, as but two cases of this affection have occurred in the wards of St. George's Hospital during several years past.

In both cases, the protruded substance certainly presented all the outward appearances of brain-matter; and in the last one, which occurred in the year 1855, bits taken away from different parts of the surface of the protrusion were, at various periods, examined microscopically: blood-cells, exudation-corpuscles, and many nerve-tubules were detected in every portion thus submitted to the glass; and this, at any rate, leaves no doubt as to the protrusion being, in some cases of hernia cerebri, formed, in part, of true brain-matter. I may add that, in this case, the first escape of brain-matter took place through a rent in the dura mater, immediately after the removal of a depressed piece of bone. No further escape of brain-matter occurred until after the fourth day, when the protrusion began to show itself; from this period it went on gradually increasing, and ultimately formed a large foul mass, portions of which sloughed off daily. Within a few days of the patient's death, however, the protrusion became much less, and the wound put on a healthier aspect. The immediate cause of death was purulent infection.

The destruction of brain-matter in some cases of hernia cerebri is sometimes very great. In a case published by M. Bouchacourt,* the destruction was so great that the lateral ventricle was laid open, and, for days, limpid fluid issued through the wound.

Is it true that the size of the hole in the bone has much influence in causing hernia cerebri? It has been generally taught, and Mr. Guthrie has stated, that protrusion of the brain 'rarely or never takes place, when a considerable portion of the skull has been lost or removed; the brain being able to expand to such an extent as the inflammatory impulse from within may render necessary.' †

But facts prove that hernia cerebri may, and does, take place even when large portions of bone have been lost. In the case of M. Bouchacourt,‡ the hernia cerebri showed itself after a piece of the frontal bone of the size of the palm of the hand had come away. I have also seen a hernia cerebri occur after a considerable loss of the frontal bone—the lower part of the perpendicular portion on the right side, and the whole of the corresponding orbitar plate. And a case occurred not long ago, at the Lock Hospital, in which hernia cerebri took place after separation of nearly the whole of the frontal bone.

There is no doubt that hernia cerebri is mainly due to inflammation of the brain, and to the effusion of serum and pus, which so commonly attend these cases. Where the brain protrudes, the cerebral substance around is for the most part congested, swollen, œdematous, and soft; yellow softening may extend more or less into the surrounding parts, and a great portion of the tissue may be broken down. Abscesses of various sizes, sometimes very large, are not unfrequently found in the hemisphere involved, and large effusions of various kinds fill the ventricles. And, in addition to all this, there is generally extensive effusion of lymph and pus, both in the cavity of the arachnoid and in the sub-arachnoid tissues.

Hernia cerebri may present itself in any part of the skull. It occurs, however, by far more frequently about the vault of the skull, and especially the frontal and parietal regions; but these localities are, it must be remembered, precisely those in which injuries with loss of bone occur also most frequently. Hernia cerebri is rarely found in fractures of the base, and for this reason, that in the great majority of instances the injury to the bone is here a simple fissure, and without any laceration of the dura mater. Whenever a fracture of the base is accompanied by a large-enough separation between the fragments, or by loss of bony substance, as well as by a laceration of the dura mater, then there is no doubt that hernia cerebri may arise. Such fractures are, however, very rare.

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* *Bull. de la Soc. Anat. de Paris*, t. xiii. p. 13.

† *Inj. of the Head*, p. 138.

‡ Loc. cit.

One of the most striking cases of hernia cerebri at the base of the skull was under the care of Mr. Cæsar Hawkins, a few years ago, at St. George's Hospital. The patient, a boy, aged eleven, accidentally shot himself with a horse-pistol loaded with a bullet, which smashed the right malar bone below the orbit, and then lodged in the head. After he had recovered from the first effects of the accident, he went on without any marked cerebral symptoms for seven days, when he became restless, and then delirious; in the afternoon, brain-matter and blood began to be discharged, and a soft fungus-like growth showed itself in the wound, and the patient died, insensible, about thirty hours afterwards. At the post-mortem examination, considerable quantities of brain-matter were found protruding through the large gap made by the bullet in the sphenoid and temporal bones. The substance of the brain around the protrusion was vascular, and of the yellow colour usually found in such cases. The hernia cerebri in the middle fossa of the base of the skull is now in the Museum of St. George's Hospital.

Under fit circumstances, the protrusion may occur at an earlier or a later period—it may be days, it may be weeks. After the removal of the bone everything may appear to be going on well for a long period—as long, in fact, as the dura mater remains entire; but, should anything lead to the giving way of this membrane, and should this be accompanied by inflammation of the parts beneath, protrusion may, at any time, as already mentioned, be the consequence. There are cases on record in which the protrusion did not come on until after the second month, and some are mentioned in which the interval was even longer. The usual period, however, for such protrusions is generally at the time when inflammatory symptoms are most apt to set in—that is, within a few days after the injury. Mr. Guthrie* states that those protrusions which are principally composed of coagulated blood usually appear immediately after, or within two days after, the accident; and that those formed of brain-matter occur at a later period, usually, although not necessarily, when the first or active inflammatory symptoms are on the decline. Facts do not, however, bear out any such rule.

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* Op. cit. p. 138.

The blood-tumour may show itself at a period much later than that mentioned by Mr. Guthrie. In Abernethy's case, for instance, it did not appear until the tenth day after the removal of the bone. And necessarily such a tumour must vary very much as to the time of its appearance. Being, in some cases, dependent upon blood extravasated at the time of the accident, the protrusion may occur at a very early period; being, in other cases, dependent upon blood extravasated, from various causes, into the soft and over-luxuriant granulations, it cannot come into existence until later. And the protrusion of true brain-matter—and by this is not meant the escape of brain-matter which immediately follows the accident or the operation—may appear within three or four days. I have seen it on the fourth day.

What is the course of such tumours? Varying in shape and in size, according to the hole in the dura mater through which they have to pass, such tumours gradually increase in bulk, and sometimes form a large mass, overlapping and completely covering the wound in the scalp; in their progress, portions break down, become sloughy, and disappear; and, under favourable circumstances, the whole tumour may thus, in the course of time, waste away, and cicatrisation of the wound follows; or, as the daily wasting takes place, further protrusion ensues, going on and on for days and days, until the patient dies: and, in some rare cases, such a protrusion has been brought suddenly to an end by the patient tearing away the whole tumour, and recovery has ensued. And experience has also proved that the protrusion may shrink, waste away, and at last disappear totally without any sloughing.*

But in the majority of cases the patient sinks, sooner or later, under the inflammatory processes going on within the skull. And hernia cerebri is certainly a most formidable, and most frequently a fatal, affection; not so much, however, on account of the protrusion, as of the circumstances which gave rise to it. Still there are on record a goodly number of cases in which patients recovered even after very large protrusions. Indeed, in one case, published by M. Spring,† the protrusion is said to have involved the whole of the left hemisphere; notwithstanding which, the patient got well and lived for eleven years afterwards, and at the post-mortem examination the left side of the cranium is said to have been found quite empty.

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* Laurie, *Lond. and Ed. Month. Jour.* June, 1844, p. 478.

† *De la Hernie du Cerveau*, 1853, p. 72.

As to the symptoms accompanying hernia cerebri, they are those of inflammation of the brain and its membranes, running its various courses, and such as exist without any protrusion. But, in some cases, large protrusions of brain-matter may be seen with daily sloughing and reproduction, and yet with but few symptoms, and those only slightly marked. In the case referred to at page 324, of extensive protrusion from the anterior lobe of the right hemisphere of the brain, under the care of Mr. Cæsar Hawkins, at St. George's Hospital, the patient rambled a good deal, but, when spoken to, always readily answered every question put to him: there were some few and occasional twitches about the muscles of the face, and the motions and urine were passed unconsciously. The protrusion became larger and larger; portions of it sloughed away daily, and the only additional symptoms were an occasional fit of syncope, from which the patient soon rallied after taking a little wine, and some loss of power about the right arm: and this was all. The patient ultimately died from purulent infection.

The treatment of hernia cerebri is to be of the simplest kind. The less the protrusion is meddled with, the better. As a general rule, removal, either by tearing away, slicing off, or ligature, is to be avoided. The parts are to be kept as clean as possible, for which purpose, gentle syringing, either with cold water or some slightly astringent lotion, may be resorted to; and the best local application is that simply of cold water. In the earlier stages, when the tumour is but small, gentle pressure may be advantageous; but in the larger protrusions, it should be abandoned. The general treatment of such cases is that appertaining to intra-cranial inflammation, varying according to the symptoms and the condition of the patient.

And from all this it follows, that all causes which may lead to irritation and inflammation of the parts within the skull should, if possible, be carefully removed. No splinter, no depressed fragment of bone, no foreign body should be left, if it can be got away without undue risk. At the after-death examination of one case of hernia cerebri which fell under my notice, several pieces of bone were found firmly fixed to the outer surface of the dura mater, and there was one larger fragment, of a triangular shape, which had pierced the membranes, and was sticking in the brain. The same fact has been noticed, and especially dwelt upon, by several surgeons.

Lastly, I would add, that we must be very careful, when operating, to avoid all injury to the dura mater. To admit of a protrusion of the brain, there must be, in addition to the removal of the bone, an opening of some kind in the dura mater. This membrane may not have been injured by the accident, but it may slough in consequence of being roughly dealt with at the time of the operation. We cannot, therefore, be too careful how we handle the dura mater whenever we are called upon to remove any bone; and to the evil of depriving this membrane of its outward covering we must be especially careful not to add that of unnecessarily touching and fingering it after an operation.

Injuries of the Cerebral Nerves.

In connection with injuries of the head, one or more of the cerebral nerves are sometimes found seriously affected in their functions; and should the patient survive, this affection, however alarming at first sight, may sooner or later pass off altogether, or nearly so; or paralysis of the cerebral nerve may remain, and, in fact, be the only evidence of the patient having had a severe injury of the head.

Traumatic affections of the cerebral nerves may co-exist with, and be produced by, very different injuries of the head.

The nerve may be torn or otherwise injured by the instrument which produced the fracture. This, however, is upon the whole a rare form of injury; but some nerves are by their situation and connections rendered more liable to it than others. For instance, the olfactory, and more especially the optic and other nerves of the orbit, may be injured in a thrust-wound; and such wounds, although rare, are as already mentioned, occasionally met with in civil hospitals.

Closely connected with, and passing through, holes and canals in the bones, the cerebral nerves may be torn or injured by a fracture implicating the base of the skull. And here again it will be found that some nerves are very much more liable to injury than others. Of all the cerebral nerves, the seventh pair, for instance, is thus injured much more frequently than any other nerves. This is easily explained by the relative frequency of fractures cutting across the petrous bone, and involving the long bony canal through which these nerves have to pass; and, for ages, paralysis of the facial or of the acoustic nerve has been held as a valuable sign of fracture of the base in severe injuries of the head. But, on the other hand, it must not be taken for granted, that in every such case of paralysis the petrous bone has been broken and the nerve torn. The paralysis may, after some little time, pass off, and then it is evident that the affection of the nerve must have been connected with some other form of injury. Other nerves are liable to injury from their close connection with a piece of broken bone, and this, too, away from their bony canal.

Again, paralysis of the cerebral nerves may be dependent upon a traumatic effusion of blood at the base of the brain. And this extravasation may affect the nerve, either by pressing upon it in some part of its course, or by pressure upon the part of the brain connected with the nerve. The extravasation may ultimately be absorbed; and thus is explained that form of paralysis, not unfrequently observed about some of the cerebral nerves after an injury of the head, which lasts for a longer or a shorter period, and then gradually disappears.

The injuries of the various cranial nerves, viewed separately, present some points of especial interest, which must now be considered.

First pair.—The olfactory may be torn across in a fracture of the base of the skull. It was so in a soldier in whom the ethmoid had been broken to pieces by a bullet.* But paralysis of this nerve not unfrequently occurs in cases where the head has been severely injured, without any direct evidence of fracture. In such cases we are led to suppose that an extravasation of blood was, in all probability, the cause of the paralysis of this nerve, and this extravasation may have affected either the nerve itself or the adjacent part of the brain.

In looking into these cases it will be found that the loss of smell followed such an injury as might lead to the anterior lobes of the brain being driven against the bones, and bruised. And, tightly bound down in the greater part of their course to the brain by the arachnoid membrane, the olfactory nerves may in this form of injury occasionally be more or less bruised, or pressed upon by an extravasation of blood.

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* Jobert, *Plaies d'armes à feu,* p. 139.

In one case mentioned by Sir B. Brodie,[*] a gentleman met with an injury of the head which deprived him of the sense of smell. After some time, however, he began to recover from this symptom, and at the end of a year his smell was completely restored. And in another case,[†] where the loss of smell also followed a severe injury of the head, this symptom persisted without the slightest improvement many years afterwards.

In relation to the loss of smell, great care must be taken lest there be some error as to the existence of this symptom. In a case in St. George's Hospital, some years back, the patient, who was suffering from a traumatic paralysis of the face, appeared for several weeks to have lost the sense of smell upon the left side; even the strong liquor ammoniæ produced no effect, save that of lachrymation. At length it was discovered that, owing partly to a deflection of the septum towards the left side, and partly to the imperfect action of the muscles, the left nostril had, under ordinary circumstances, become impervious to air. On dilating the left nostril artificially, it was found that the patient could smell equally well on both sides.[‡]

Second pair.—The optic may be torn across in a fracture of the orbit.

In the case of a child, over whose head a cab-wheel had passed, the roof of the orbit, in addition to other extensive fractures, was broken up into fragments, and the optic nerve and straight muscles were completely torn through.[§]

This nerve is also so circumstanced that it may be pressed upon by a fragment of broken bone away from its foramen, so as to give rise to total blindness.

Such was the case in an old man admitted into St. George's Hospital after having been run over by a cart. There was a fracture with depression of one of the parietal bones; but the most marked symptom was total blindness, which was explained, at the after-death examination, by the optic nerves, immediately behind the orbits, being pressed upon by the broken sphenoid bone.[‖]

But loss of sight may also be caused by pressure from an extravasation of blood connected with a fracture of the base. And this extravasation may lie either within the skull or in the orbit.

In M. A. Richard's case,[¶] with evident signs of fractured base of the skull, the orbits were filled with blood, and especially the left, on which side total loss of sight was observed on the following day. The blood in the orbits was gradually absorbed, and the sight of the left eye was completely restored within a month. In this case, the loss of sight was due, it was thought, to the blood extravasated in the orbit; but, in reference to this point, I would especially direct attention to the extravasation of blood which, after severe injuries of the head, sometimes takes place within the neurilemma of the optic nerve as it lies in the orbit. In severe injuries of the head, and especially those about the orbits, I have several times seen the neurilemma of the optic nerve distended with blood, which had evidently proceeded from the veins contained within this sheath. In the Museum of St. George's Hospital are two optic nerves, both taken from the same patient, in which these appearances are well marked.

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[*] *Med.-Chir. Trans.* vol. xiv. p. 365.

[†] *Med.-Chir. Trans.* vol. xiv. p. 421.

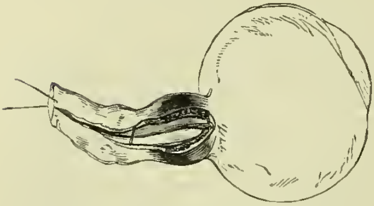
[‡] *Med. Times and Gazette,* 1852, new ser. vol. iv. p. 240.

[§] *Bull. de la Soc. Anat. de Paris,* 1837, p. 228.

[‖] *Med.-Chir. Trans.* vol. xiv. p. 348.

[¶] *Gaz. des Hôpit.* 1854, p. 446.

Fig. 58.



Extravasation of Blood in sheath of Optic Nerve.

Such extravasations deserve, I think, more than a passing notice, for it seems to me that blood thus situated will serve to explain some of those cases in which blindness has existed for some time after an injury of the head, and then gradually disappeared. In such cases, the nerve-fibrils are not torn or injured; the neurilemma is simply cram-full of blood; and as this blood becomes absorbed, sight is restored. And thus it is that I would explain M. A. Richard's case. The orbit was, it is true, filled with blood; but as it is not stated that the effusion led to the least protrusion of the eye-ball, I think it more than probable that the pressure on the optic nerve was from blood within its sheath, and not from the blood in the orbit. And then, again, it is expressly stated in this case that none of the other nerves of the orbit were affected, which they, in all probability, would have been, had the paralysis of the optic nerve depended solely upon the blood in the orbit.

Third pair.—From its connections, the third pair of nerves is less liable to injury from broken bone than most of the other cerebral nerves. But it is liable to pressure from extravasated blood. A case of paralysis of the third nerve, in a fracture of the skull, is referred to by MM. Denonvilliers and Gosselin,* in which a clot of blood was found lying in the space between the crura cerebri. And Sir B. Brodie † states that he has 'known a ptosis of the *left* upper eyelid connected with pressure on the inferior surface of the *left* hemisphere of the cerebrum; the pressure being so situated as to affect the nerve of the third pair immediately behind the left cavernous sinus.'

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* *Mal. des Yeux*, p. 821. † Loc. cit. p. 351.

After an injury of the head, all the branches of the third pair of nerves may be paralysed. But it is curious to observe how much more frequently it is a single branch of this nerve which is thus affected. For instance, there may be ptosis of the upper lid, and this may be the only part paralysed. Why one branch alone of this nerve should be thus singled out from all its other branches it would be impossible to say: not only may this be the case, however, but one branch of the upper division of this nerve, and another branch of its lower division, may be paralysed at the same time, without any of its other branches being affected. It is a matter of especial interest that we should note that there may be ptosis and a dilated, immovable pupil.

A gentleman* fell from his horse, received a severe contusion of the head, and was taken home labouring under manifest symptoms of pressure on the brain. When, after the lapse of several days, these symptoms became somewhat abated, it was observed that the pupil of the right eye was dilated, and incapable of contraction; but his power of vision was unaffected. This symptom was accompanied with a ptosis of the right upper lid, and a numbness of the right hand. Nearly a year elapsed before the pupil was restored to its natural condition.

A man† fell from a height and alighted on his head: amidst other severe symptoms, it was noted, four weeks after the accident, that the left upper lid was paralysed, and the left pupil dilated, with some impairment of the sight. The right pupil was natural. These symptoms gradually wore off; and the power of the upper lid, and the sight, were completely restored, within some thirteen months after the injury.

In both these cases it is especially worthy of note that the paralysis disappeared after a time. In the latter case it is mentioned that there was some impairment of the sight; and this might lead to the supposition that the optic nerve, too, was in some degree affected. There is no proof, however, that such an affection did in truth exist; the impairment of the sight may have been, and most probably was, owing to the dilatation of the pupil; but a simple contrivance—a card pierced with a small hole—would have settled this point.

Fourth pair.—As to the pathetic nerve, I know of no case in which it was found torn or bruised in a fractured base. The relations of this nerve with the surrounding parts will easily explain this apparent immunity from direct injury; and, even were this nerve pressed upon by extravasated blood, with our imperfect knowledge of the action of the superior oblique muscle, the exact diagnosis of a palsy of this muscle would, I think, be most difficult.

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* *Med.-Chir. Trans.* vol. xiv. p. 354.

† *Lond. and Edinb. Month. Journ.* Sept. 1843, p. 797.

Fifth pair.—Affections of this nerve have not unfrequently been met with after injuries of the head, the paralysis manifesting itself upon one or more of its branches, and this, too, combined, for the most part, with palsy of some other cerebral nerve.

A man,* aged thirty-five, having, the day before, been buried by some earth falling in upon him, was admitted into the Hôpital St. Antoine, in June 1854, in a state of perfect insensibility, and with such profuse bleeding from the nose, that it became necessary to plug his nostrils. The ocular conjunctiva, especially on the left side, was distended with blood, and so, too, were the eyelids. He gradually recovered, and then paralysis of various nerves became evident at different periods. The right upper lid and eyeball lost all power of motion. A few days afterwards, and paralysis of the right side of the face was observed; it was not quite complete, but both sensation and motion were manifestly affected. Ten days after the patient had been in the hospital, the conjunctiva of the right eye was œdematous and much chemosed; the cornea could be touched freely without flinching; it had lost some of its transparency, and, at its lower part, there was a yellow spot like an interlamellar abscess. Towards the end of the month, the cornea presented a slight ulceration opposite to the yellow spot, and the facial paralysis was even more marked. Matters went on much in the same way during the month of July, with more ulceration, however, about the eye, and less paralysis of the face. Early in August the cornea gave way, and the aqueous humour escaped. Later on in the month the patient began to improve; subsequently the right cornea cicatrised, and he could see from the upper part; and, ultimately, both sensation and motion were restored to the right side. Such, as far as the fifth pair of nerves is concerned, are the details of this most interesting case.

One more case of palsy of the fifth pair. The man† was in St. George's Hospital in the year 1841. At the time of his admission, seven weeks after a very severe injury of the head, there was total loss of sensation on the left side of the face and upper part of the head—in fact, in every part dependent upon the fifth pair of nerves; there was no sense of taste or of feeling on the left side of the tongue, except at its root, and no consciousness of any sensation when a probe was introduced into the left nostril; and the muscles of mastication on this side had less power. Several other nerves were also seriously affected. His history was, that he had fallen from a height of twenty-eight feet, a heavy piece of timber at the same time falling upon the left side of his head. The accident was followed by perfect insensibility, for several hours, and the loss of a large quantity of blood from the ears, nose, and mouth; there had been paralysis of the right side of the body, but from this he had recovered. His intellect was sound, and he answered all questions with great precision. Very little improvement followed, notwithstanding various plans of treatment. The power of raising the left upper lid was regained, but the cornea of the left eye gradually became opaque. And when seen, many years afterwards, this man was much in the same state, save that the cornea had become somewhat more transparent.

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* *Gaz. des Hôpitaux*, 1854, p. 446; A. Richard.

† *Med. Times and Gaz.* 1852, p. 240; Henry Lee.

Such is traumatic paralysis of the fifth pair of nerves; caused in some instances, no doubt, by pressure from extravasated blood, and in other instances again by some more permanent injury; at times passing off within a few weeks, at other times abiding year after year. The cases which have been mentioned were, moreover, especially selected in reference to the subsequent condition of the cornea. In the first case, in which the affection of the nerve was incomplete, and passed off altogether within four months, the cornea sloughed; but in the other case there was no sloughing of the cornea, notwithstanding the perfect palsy of many years' standing. Both cases afford good examples of the two forms of diseased action referred to in Mr. Dixon's* valuable paper on anæsthesia of the fifth nerve.

Sixth pair.—Paralysis of the abducens nerve occurs sometimes after an injury of the head; it may exist alone, or be combined with paralysis of several other branches. The sixth nerve may be torn across in a fracture of the base; indeed, its close connections with the petrous bone render this nerve liable to direct injury. From its slender size, and passing as it does in a groove on the superior border of the petrous bone, the sixth nerve may be snapt across in a fracture of this part of the base.

A man† fell from a height, and alighted on his face. He never lost his senses; merely felt shaken; walked home, and returned to his work next day. Four days afterwards, however, he began to suffer from head-symptoms, and three weeks from this time it was noticed that the right eye was drawn inwards. He went on from bad to worse, and died at the end of four months. A fracture was found running across and detaching the inner third of the right petrous bone, and opposite to this the sixth nerve was snapt asunder.

In this case, the sixth was the only nerve injured; and thus it was also in another instance, mentioned by M. Aran,‡ in which a man, after receiving a violent blow on the head, lost all power of moving the eye outwards. There was a distinct squint, for which he was operated upon by M. Maisonneuve; but with very little or no benefit.

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* *Med.-Chir. Trans.* vol. xxviii. p. 373.

† *Journ. l'Expér.*, nov. 1843.

‡ *Arch. Gén. de Méd.*, nov., 1844, p. 338.

Paralysis of the abducens not unfrequently co-exists with that of some of the other cerebral nerves. Of this there are several cases on record, in which this nerve, as well as the others, gradually regained its power.

Seventh pair.—As for the facial and the acoustic, paralysis of these nerves is one of the common signs of fracture of the base of the skull. Connected as these branches are with the petrous bone, they may be, and are frequently, torn across in a fracture implicating this region. And although so closely connected—bound up in the same sheath—lodged in the same canal—one of these nerves may be injured, and not the other. Facial paralysis not unfrequently exists without deafness; and sometimes there is marked deafness, without any affection of the muscles of the face. The paralysis may be strongly marked, but it may pass off in a few months. In such cases the injury may have consisted in an extravasation of blood within the tubular sheath of the arachnoid belonging to these nerves. I have seen a small clot of extravasated blood lying between the nerves, at the bottom of the meatus internus.

Eighth and ninth pairs.—Affections of these nerves occur but seldom after injuries to the head. The bony canals through which these nerves pass are short, and the nerves themselves lie in the region of one of the large sub-arachnoidean spaces, the fluid of which would, by its displacement, allow room for blood to be extravasated without any great amount of pressure.

Should an affection of these nerves thus occur, however, the symptoms, in such cases, are certainly most distressing; but, however distressing, they are not always fatal, and they may even disappear altogether. A forcible illustration of this will be found in the two following cases.

In one instance* mentioned by Mr. Hilton, with paralysis of some other cerebral nerves, it is particularly noticed that the patient manifested much difficulty in swallowing; the tongue was thrust over to one side; articulation was slow, and enunciation very imperfect; and there was pain extending down the neck, on the side affected, as far as the clavicle. The patient had bleeding from the ears, nose, and mouth, after an injury of the head; but he recovered in a few months, and with only slight traces of paralysis left.

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* *Lancet,* 1853, vol. i., p. 421.

A grenadier* was struck in the region of the posterior superior angle of the left parietal by a lance, which passed deep into the substance of the brain. The lance was withdrawn a few hours afterwards, and the wound healed rapidly. The intellect was as good as it was before the injury, but the glosso-pharyngeal, the par vagum, the hypoglossal, spinal-accessory, and sub-occipital, were all paralysed. Aphonia, dysphagia, dyspnœa, with contractions of the muscles accessory to respiration—more or less paralysis of the pharynx, œsophagus, and stomach—so that large doses of emetics had no effect;—such were some of the most distressing symptoms presented by this poor fellow.

One more case, in which the eighth pair of nerves became affected, must be mentioned, as it shows what consequences may arise by subsequent displacement of the fractured bones in an injury of the base.

A man † was admitted into Guy's Hospital with symptoms of concussion of the brain, and fractured base of the skull. He went on well until the tenth day, and then, after getting out of bed, and walking across the ward to talk to his wife, he was seized with rigors and vomiting, and gradually fell into a semi-unconscious state. Towards the evening appeared difficulty of swallowing, and the breathing became gasping. The difficulty of swallowing increased; and before the morning everything was rejected as soon as it reached the pharynx. He died of coma and asphyxia, within forty-eight hours after the setting-in of the serious symptoms. The brain and its membranes were healthy; there was no appearance of anything like inflammatory action; neither was the brain bruised or lacerated. A line of fracture intersecting the right foramen lacerum posterius, and running across the base, divided this part of the skull into an anterior and a posterior portion, freely movable upon each other; and the bones here were so displaced, that the right cerebellar fossa was lower than the left.

In commenting upon this case, Mr. Hilton very justly remarks that the difficulty of swallowing and breathing, which suddenly made its appearance after the man's walk across the ward, was, in all probability, caused by the displacement of the bones at the foramen lacerum posterius—a displacement by which the eighth pair of nerves was irritated, if not severely pressed upon. And as there was not the slightest trace of inflammation about the brain or its membranes, this, no doubt, is the right explanation of the symptoms which so suddenly made their appearance.

And this view of the case is borne out by Sir C. Bell's ‡ two cases, in which sudden death was caused by the after-displacement of fractured portions of the foramen magnum, and consequent pressure upon the medulla oblongata.

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* Chassaignac, *Plaies de Tête*, p. 93.

† *Lancet*, 1853, vol. i. pp. 24, 25, 147.

‡ *On the Nervous System*, 3d edit., cases cxlvi.-cxlix.

Special treatment in injuries of the cerebral nerves seems to be of but little avail. If dependent upon extravasated blood, or any other cause removable by the efforts of nature, the paralysis will gradually disappear in the course of time; but I know of no particular plan of treatment which will help us much in such cases. At least, mercury, blistering, and other remedies usually resorted to, have not, as far as I have seen, produced any very marked benefit. And in using electricity we must be very careful lest it produce disturbance about the head, which it is apt to do, especially if employed at too early a period after the injury. On the whole, I should, in all cases of traumatic paralysis of the cerebral nerves, trust much to the restorative powers of nature.

Traumatic Inflammation of the Brain and its Membranes.

All injuries of the head, of whatever kind, may lead to inflammation within the cranium. Injuries of the scalp, apparently of the most trifling nature; injuries of the bones; injuries of the brain-substance;—all may give rise to intra-cranial inflammation. But some of these injuries are more apt to give rise to this inflammation than others, and, as might be readily anticipated, injuries of the brain-substance are, more frequently than any other injuries, followed by this kind of mischief.

In a wound of the scalp followed by erysipelas or diffuse cellular inflammation, cerebral symptoms often supervene; and should the patient die, the morbid appearances in the majority of cases are limited to great congestion of the brain-substance, with increased vascularity of the pia mater, and effusion of opaque fluid in the sub-arachnoid tissues at the upper surface of the hemispheres.

Inflammation spreading inwards from an injury of the bone or of its coverings may be traced, as it were layer by layer, from the outer parts down to the brain; first involving the dura mater, then the parietal arachnoid, the visceral arachnoid, the pia mater, and ultimately the cortical substance of the brain.

The inflammation of the dura mater may be marked by increased vascularity, thickening, and closer adhesion to the bone; such appearances belong, however, more especially to a chronic form of mischief set up by inflammation, caries, or necrosis of the bone after an injury. In the more acute inflammation, and above all in suppuration of the osseous tissue, the outer surface of the dura mater is covered by lymph, or by pus; its tissue gets infiltrated; it may pass on to sloughing. As far as the dura mater itself is concerned, the mischief is generally confined to that part of the membrane directly under the diseased bone; but even here, in particular localities, it sometimes happens that the inflammation spreads along the cellular tissue which surrounds the branches of the meningeal arteries, and by this means reaches even down to the base of the skull.

In the acute cases, the inflammation, involving as it does the whole thickness of the dura mater, lays hold also of its inner surface, the parietal arachnoid, a part and parcel of the dura mater; and having once reached this serous membrane, the inflammation usually and rapidly becomes wide-spread. The inflammatory effusion on the free surface of this membrane is but very seldom limited to the spot first implicated. This I have, however, seen once. Under an exposed piece of bone, the dura mater was inflamed, thickened, and partially detached; and exactly limited to this spot, there was an effusion of lymph and pus on the parietal layer of the arachnoid; but all the other parts of the membranes and of the brain were quite healthy.

This is an exceptional instance, and in the vast majority of cases the parietal arachnoid is extensively inflamed, and the cavity of this membrane is filled with a quantity of fibrinous or of puriform exudation of a yellowish or yellowish-green colour. The effusion seldom extends, however, beyond the upper and lateral surfaces of the hemispheres; sometimes it spreads over one hemisphere only, that corresponding to the injured bone; sometimes it is found on both hemispheres, but without any effusion at the base of the skull. Occasionally, the puriform is circumscribed by the fibrinous effusion, which may, moreover, unite the two layers of the serous membrane to each other around this part; and thus is formed within the arachnoid that kind of circumscribed collection of matter which may be, and has been, mistaken for an abscess in the brain-substance. As an instance of this, I would more especially refer to De la Peyronie's * celebrated case of abscess of the brain, which was, I think, simply a collection of matter circumscribed in the cavity

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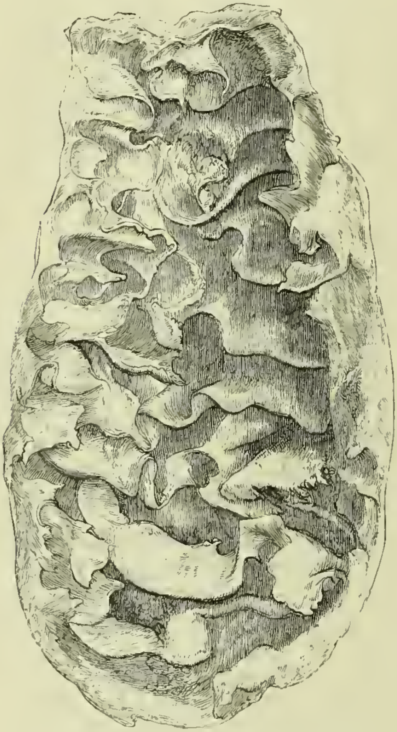
* *Mém. de l'Acad. des Sc.* 1741: 'Sur le Siége de l'Ame.'

of the arachnoid, and running down by the side of the falx, as far as the corpus callosum. This view of the case is, I think, borne out by Pott's * and Soulier's † cases, and by a case in which I found a collection of matter in the cavity of the arachnoid thus circumscribed and running down between the left hemisphere of the brain and the falx, as far as the corpus callosum. The depth to which the matter passed in this case might easily, during life, have led to the supposition that the collection was in the brain itself.

Fig. 59.



Pia-mater thickened from Inflammation.

From the arachnoid the inflammation spreads to the pia mater, and here, too, there is an extensive fibrinous or puriform exudation of a yellowish or yellowish-green colour. The meshes of this membrane are filled with the effusion; and such is the thickened condition of the pia mater, in the severer cases, that it may be removed whole from the brain, and with its prolongations, which dipped down between the convolutions, looks as if it had been cast in wax. Of this there are excellent specimens in the Museum of the Royal College of Surgeons, and in that of St. George's Hospital.

As in the arachnoid, so here, in the pia mater, these appearances do not generally extend beyond the convexity of the hemispheres. And all that part of the cortical substance of the brain corresponding to the inflamed and thickened pia mater is often of a dark, leaden hue; it may be, too, adherent to this membrane, and softened, and easily torn; so that, in

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[*] *Inj. of Head*, p. 107.

[†] *Mém. de l'Acad. de Chir.* t. i. p. 159.

endeavouring to pull off the pia mater, it not unfrequently happens, notwithstanding all our care, that patches of brain-substance, varying in size and thickness, come away with the membrane.

In all this, the grey matter alone, and sometimes only a thin layer of it, is involved: as to the white substance of the brain, it is simply congested, the bloody puncta being larger and more numerous than usual.

Such are the usual appearances when inflammation spreads inwards from an injury of the bone or its coverings. But occasionally it happens that the appearances in these cases differ somewhat.

On the one hand, there may be extensive effusion into the cavity of the arachnoid without any effusion in the pia mater: thus, in a case where matter was lying between the bone and the dura mater, the corresponding cavity of the arachnoid was filled with pus and lymph, covering the posterior third of the upper and lateral surface of the hemisphere, but there was no effusion in the sub-arachnoid tissues. Of this there are two equally well-marked cases mentioned by Sir T. Watson;* but according to my own experience, such cases are very rarely met with.

On the other hand, with an inflamed dura mater, covered it may be, with lymph and pus, it sometimes happens that the arachnoid escapes, and this, too, notwithstanding an extensive effusion in the sub-arachnoid tissues. In a case in which the dura mater on the left side was covered with a patch of concrete lymph, and matter running from thence along the branches of the middle meningeal artery down to the base of the skull, no effusion was found in the cavity of the arachnoid; but there were large quantities of sero-purulent fluid in the sub-arachnoid tissues covering the whole of the left hemisphere.

Such a case is a very uncommon one. There is no doubt that, in the great majority of instances of meningitis arising from an injury of the bone, the inflammatory effusions are poured into the cavity of the arachnoid. But how very rarely is anything like exudation met with in the arachnoid in the idiopathic form of inflammation! And when this marked difference between traumatic and idiopathic arachnitis is spoken of, it must be borne in mind that it is especially in this form of traumatic inflammation, arising from an injury of the bone, that the great difference exists. Traumatic inflammation of the membranes arising from an injury of the brain resembles the idiopathic form of inflammation, inasmuch as the cavity of the arachnoid is, in both forms, most frequently free from effusion.

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* *Pract. of Phys.* 3d ed. vol. i. pp. 368, 369.

In looking carefully to the inflammatory appearances of the membranes after concussion or contusion of the brain, the exudation will, for the most part, be found on the outside of the arachnoid, and more or less extensively infiltrating the pia mater. It is only in cases where the inflammation is very severe that effusion takes place on the free surface of the serous membrane. The exudation itself resembles that which is commonly found in inflammation of the pia mater; if puriform, it is greenish, and not unfrequently of a decidedly green colour.

There are, then, two kinds of traumatic inflammation of the membranes of the brain. The one, commencing in the dura mater, and almost always reaching the free surfaces of the arachnoid; the other, commencing in the pia mater, and seldom passing beyond this membrane, and that only when the inflammation is very severe. The one, starting as it were from the bone, affects the membrane nearest to it, the dura mater; and the other, starting from the brain, here also affects the nearest membrane, the pia mater. Whilst dealing with concussion of the brain, it was particularly mentioned that intense vascularity is one of the peculiar features found about the brain-substance when death takes place some short time after the accident; and well can it be imagined that this intense congestion of the brain, if it does not pass off, will react on the pia mater; and hence the inflammation which, in such cases, manifests itself in this membrane.

Injuries of the head may also lead to inflammation of the brain-substance; and this traumatic inflammation may affect either the cortical substance only or the deeper parts of the brain. Inflammation of the cortical substance may follow an injury of the bone, as in those cases, for instance, in which the inflammation may be traced through the various membranes to the brain, the grey substance of which, of a leaden hue, is softened, and easily carried away in peeling off the membranes.

This, doubtless, is an inflammatory process affecting the cortical substance.

Traumatic inflammation of the cortical substance may also be detected in those cases where meningitis supervenes after simple concussion of the brain. Even at an early period the inflamed grey matter, of a dark-red hue, is swollen and soft, thin patches of it coming away with the pia mater, which itself is very vascular. Later on, effusion takes place in the pia mater, and the grey matter, of a darker colour, breaks up and washes away under a gentle stream of water, leaving bare the white matter, much increased in vascularity, but not softened. This inflammation of the grey matter is remarkable for its extent; in many cases it occupies a whole hemisphere save the base, which generally remains unaffected.

But inflammation of the brain most frequently follows contusion and laceration of its substance. Simple concussion seldom leads to fatal inflammation, and rarely does an opportunity happen of examining the after-death appearances in a case of this kind. In the great majority of the so-called cases of concussion in which death takes place, the inflammatory process is found to be connected with, and arises from, an actual and appreciable lesion of the brain-substance.

Should the patient survive the accident for a few hours only, the whole structure of the brain, and especially that around the injured part, becomes extensively congested; so that it will require some little care to distinguish between the specks of extravasation and those of congestion. At a later period, the brain-tissue around the injured spot is of a duskier hue throughout, and the texture swollen, moist, and loose. Then follow the inflammatory exudations, reducing the substance of the brain around to a soft pulp of various colours, which flows away under a gentle stream of water, leaving the remaining part broken down and shreddy. These appearances do not generally extend much beyond the original seat of the injury; but sometimes the greater part of the hemisphere becomes involved: the white substance is then of a peculiar saffron colour, which grows fainter and fainter on the outskirts, and the whole tissue is loosened and diffluent; and even should this appearance of disintegration not be at first sight plainly perceptible, it may easily be demonstrated by dropping upon the part a little water from a sponge.

Softening of the central white parts of the brain is very seldom met with after an injury of the head. The following are the only two cases which have fallen under my own observation. A man, aged thirty-seven, died twenty-four hours after an injury of the head in a fall from a tree: the ventricles were found dilated and filled with fluid, and the fornix—remarkably soft—gave way when slightly touched: at the base of the brain, around the pons and medulla oblongata, there was a large quantity of milky puriform fluid: the substance of the brain was firm, and the puncta of blood larger and more numerous than usual: the cribriform plate of the ethmoid was broken, and the corresponding part of the brain bruised. A lad, aged thirteen, died, about three weeks after he had been thrown from a donkey and fallen on the back of his head. The ventricles were enormously dilated, and filled with serum and recently-effused lymph, and the central white parts of the brain were very soft, and broke down when slightly touched; the grey and the white substances of the brain were, throughout, very much congested, and there was extensive inflammation of the membranes; a slight fissure was found in the occipital bone, extending from the lateral sinus to the foramen magnum.

All traumatic inflammations of the brain-substance may end in suppuration and abscess, and this after contusion and laceration, and even after simple concussion. Of this I have seen two well-marked instances at St. George's Hospital within the last few years. In both cases the abscesses were large ones, and in both the formation of matter followed simple concussion.

An abscess, situated in the brain, may burrow, and burst into the ventricles: such an occurrence soon proves fatal. But an abscess in the neighbourhood either of the cribriform plate of the ethmoid, or of the petrous bone, may, by making its way through these bones, ultimately be discharged by the nostrils or by the ear, and the patient get well. In these cases of recovery we cannot, it is true, say positively that the matter came from the brain itself; it may have come from between the bone and the dura mater, or from a circumscribed cavity within the sac of the arachnoid. Still, if the discharge which takes place is copious, it may, I think, be safely inferred that the matter came from the brain itself, as a large quantity of matter is more apt to form in this than in either of the other situations just mentioned. The abscess may be situated close to the surface of the brain, and moreover it may chance to lie over a fracture; so that the matter would only have to make its way through a thin layer of brain-substance and the membranes.

The copious discharge of matter which suddenly took place from the ear, some weeks after an injury of the head, in Mr.

Cæsar Hawkins' case, may thus have come from the brain. In his report* of the case, Mr. C. Hawkins inclines to the opinion that the matter came from between the bone and the dura mater; but there are two important facts which appear to me to militate against this opinion. The one, that diffuse inflammation of the membranes almost constantly accompanies suppuration between the bone and the dura mater; and the other, that had the matter really been between the bone and the dura mater, and percolated through a fracture, it would have come away gradually as it was formed, and not in a sudden burst—in a large quantity. This it is which makes me think that the case was one of cerebral abscess which had made its way outward.

Intimately connected with this subject of traumatic intracranial inflammation, there is yet one other point which has not, I think, been sufficiently dwelt upon by most of the writers on injuries of the head. I allude to the large quantities of serous fluid which are sometimes effused into the ventricles after injuries of this kind.

Fluid is poured out into the ventricles, after an injury of the head, under very different circumstances. The effusion may occur, and this is generally the case, in connection with other mischief of a more deadly nature, with acute inflammation of the membranes. For instance: in a man who died three days after having been trephined for a compound and depressed fracture of the skull, the sub-arachnoid tissue of the upper part of the left hemisphere was extensively infiltrated with seropurulent fluid, and all the ventricles were enormously distended, and filled with a clear, transparent serum; the lining membrane being, throughout, rough, and as if sprinkled with the finest white sand. The septum lucidum was exceedingly thin. The structure of the brain was quite healthy.

But accumulation of fluid within the ventricles, following an injury of the head, may sometimes be the only morbid appearance; and this effusion may be more or less gradual: days, weeks, months, may elapse before any decided symptoms make their appearance.

Of such cases Dr. Abercrombie relates two strongly-marked instances in his work on *Diseases of the Brain*, pp. 151, 152. In both these cases the effusion was slow, and the symptoms came on gradually. But the effusion may take place suddenly; symptoms of imminent pressure are present, and, with a scalp-wound and bare bone, may lead to an error in diagnosis, and the application of the trephine.

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* *Med. Gaz.* vol. xvii. p. 262.

A middle-aged man fell in the street, and was picked up insensible, with some arterial bleeding from a scalp-wound at the upper and back part of the head; the bone was not exposed. He remained in a state of collapse for some time, and when he began to rally he became so violent that two men were obliged to hold him down. It appeared that, on the previous day, he had had, for the first time in his life, some kind of convulsive fit, but without any frothing at the mouth. He was freely purged, and on the following day, as he complained of intense pain in the head, he was bled to ten ounces. The pain continued, and thus he went on for several days with intense pain, notwithstanding that he was bled several times and put upon calomel and henbane. On the sixth day, the bone under the scalp-wound became exposed, and the soft parts in the neighbourhood slightly œdematous. On the seventh day, early in the morning, this man was seized with hiccough, and suddenly fell into a state of coma; the insensibility was complete; the pupils acted well; there was no stertorous breathing; the pulse was feeble and running. A short time afterwards, it was determined, at a consultation of several surgeons, that a trephine should be applied over the exposed bone, in case there should, perchance, be any matter between the bone and the dura mater. No matter was found. The bone and the dura mater were healthy. The patient continued much in the same state, and died in the evening. Some serous effusion was found between the arachnoid and the pia mater, especially at the base of the brain; there was no lymph in any part; the membranes were quite transparent, and the pia mater not congested. The ventricles were dilated, and filled with a large quantity of fluid; the brain itself was watery throughout, and soft. In one of the convolutions, at the base, there was a small tubercular deposit, of the size of a pea, and around this the parts were soft and injected to about three lines in circumference. No tubercular matter was found in any of the other organs, which were all sound.

What are the symptoms of traumatic intra-cranial inflammation? Amongst the first symptoms usually noticed will be pain in the head, more or less intense, sometimes confined to the seat of the blow, sometimes spreading from this over the whole head; feverishness, with a hot skin and increased pulse; contraction of the pupils; intolerance of light and of sound. As matters get worse these symptoms increase, become more and more marked, and are soon followed by disturbance of the brain-functions; sickness, restlessness, constant tossing about, convulsions, delirium; then drowsiness, oscillation and dilatation of the pupils, twitchings and spasms of the muscles, coma, relaxation of the sphincters, paralysis, and, as indicative of suppuration, rigors.

Such are the varied symptoms at different stages of inflammatory mischief following an injury of the head. In some cases all these symptoms may be present, and even manifest themselves in this regular order of succession. But in most cases the symptoms vary much in many respects. Cases may be met with in which some of these symptoms are altogether wanting; and in other cases, again, a single group of symptoms, or some one symptom or another, may be strongly marked. Indeed, in practice, it will be found that these variations give, as it were, to each case special features of its own—features which may render the case more or less difficult of diagnosis as to its real nature.

In enumerating these symptoms, injuries of the head have been spoken of as a whole. And now arises the question, whether traumatic inflammation dependent upon one form, can be distinguished from that dependent upon another form of injury. Can it be said, in this case, that the brain alone is affected, and in that case, that the mischief is confined to the membranes? I believe not.

In a case of concussion and scalp-wound, it cannot, for instance, be said positively, from the symptoms, that they depend upon inflammation of the brain-substance and its investing membranes connected with the concussion, or upon inflammation of the parietal membranes connected with a contusion of the bone. Neither can we say positively, when suppuration takes place, that the matter is immediately under the bone, or within the brain-substance. True it is that this cannot be done. But an inference, and a good one too, may, I think, be drawn from the time at which the symptoms of inflammatory mischief begin to show themselves. If the inflammatory symptoms are dependent upon concussion, they will be apparent at a very early period after the accident; indeed, in many cases, they begin within a few hours: and this is what might have been expected from the intense congestion which exists in the brain-substance and its investing membrane, the pia mater, after a severe case of concussion. In contusion of the brain-substance, on the other hand, it often, nay generally happens that the symptoms of inflammation do not set in till the fourth or the fifth day; all effects of the injury may appear to have passed away up to that period, and then comes the train of symptoms indicative of inflammation. But in inflammation spreading from a contused bone to the parietal membranes, the mischief may smoulder for a time, for many days, for two or three weeks, and then suddenly burst forth.

The period at which the inflammatory symptoms begin after the accident, may, then, be of value in our endeavours at establishing a diagnosis, and especially if there be any local signs about the bone to guide us.

Attempts have been made at a differential diagnosis of inflammation of the various parts and structures of the brain. Inflammation of the upper and under parts of the brain may be, it is said, distinguished from each other; and so, too, it is said, may inflammation of the lining membrane of the ventricles, as well as inflammation of the cortical, be distinguished from that of the tubular structure.

I cannot, however, say that I think we are at present really in a position to go so far as all this. To take an example from two of our modern teachers. 'Inflammation of the tubular portion of the hemispheres is characterised by the appearance of convulsions previous to any sign of mental excitement.' Such is Mr. Solly's* opinion. And Sir T. Watson's:† 'When the attack comes on with a sudden fit of convulsion, the inflammation has commenced in the pia mater, or arachnoid.' Can anything illustrate more forcibly the difficulties by which we must be surrounded whenever we may attempt to draw an accurate diagnosis of the exact parts of the cranial contents involved in an inflammatory attack?

It must be borne in mind that convulsions, that is, convulsions violently affecting the whole body, may make their appearance, after an injury of the head, under very different circumstances. They may come on immediately, or shortly after the accident; they may come on a few days after it. In the first instance, they can, as a matter of course, have nothing to do with inflammation; they may pass off just as suddenly as they came on, and leave the patient without a single sign to denote that they arose from any actual lesion of the parts contained within the skull. And even in the second instance, making their appearance at the period when inflammation usually sets in, the convulsions may lead us to suppose that there is inflammation, when it does not exist in reality. This I have seen now and then, and some well-marked instances of this state of things are mentioned by Sir B. Brodie.‡

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* *On the Brain,* 2d edit., p. 457.

† *Lect. on the Pract. of Physic,* 3d. edit., vol. i. p. 384.

‡ *Med.-Chir. Trans.* vol. xiv. p. 367.

Next, we have to deal with the treatment of this traumatic intra-cranial inflammation. And, first, as to blood-letting. Strange it is to read of the enormous quantities of blood drawn from patients, under such circumstances, in former times, and even but a few years back. Some cases, it is true, recovered after this heroic treatment, and nothing short of this, it is said, could have saved the life of the patient. But the practice of the present day in the wards of our large hospitals tells a very different tale. For years past, I have never seen any of those frightful blood-lettings which I used to witness in the early part of my career. Even in intra-cranial traumatic inflammation we are now-a-days much more sparing of blood—and rightly so, too.

Whenever blood is to be drawn from the arm, the general condition of the patient should be carefully looked to, and, if the loss of a few ounces only of blood produce an intermission, a sinking of the pulse, the blood should no longer be allowed to flow. The patients with whom we have to deal in the present day certainly do not require, neither could they, I think, bear the loss of much blood. I am speaking now of the patients, such as I find them in the wards of our London hospitals. They, at any rate, certainly do not require much blood-letting. If it be thought absolutely necessary to draw blood from the arm, it had better be done by small bleedings, repeated at intervals according to circumstances. It is on all accounts better to act thus circumspectly than to try to cut short the inflammatory attack by large bleedings. And in every one of our bleedings, not only ought we to look to the general condition of the patient, and the state of the pulse, but most careful should we be to examine the blood, not so much for the sake of seeing whether it is buffed and cupped, as for the relative proportions of the solid and fluid parts of the blood. A large amount of serum with a small clot tells us that we cannot with safety proceed further with our bleedings.

Some years ago, I watched a case wherein repeated bleedings, within a short time, were resorted to for supposed intra-cranial inflammation after concussion. A few hours after the last bleeding, which, although a small one, appeared to me, when ordered, not to be required, the patient suddenly became perfectly comatose and died some nine hours afterwards. There was not a vestige of pus or of lymph in any part within the skull, but large quantities of water had been effused into the ventricles, and some water was also found in the sub-arachnoid tissues. The other organs were all healthy. I have always thought that this patient died of over-bleeding.

In many cases, after the first bleeding from the arm, it is most advantageous, should further blood-letting be deemed indispensable, to resort to local bleeding by means of leeches applied to the head, or cupping on the nape of the neck. It was a favourite practice with Sanson to have leeches applied 'en permanence,' in different parts of the head, at different times; and especially on the temples, and over the mastoid processes.

As a matter of course, the room is to be darkened, the head shaved, and raised higher than usual.

Purging, free purging, is to be brought into play as soon as possible. It is a most valuable remedy, and one upon which all practical men very justly lay great stress, and none more so than Dr. Abercrombie, who does not hesitate to say that, according to his own experience, more recoveries from head-affections of the most alarming aspect take place under the use of very strong purging, than under any other mode of treatment.

And then comes the local application of severe cold to the shaved head. This is a powerful remedy, and not to be used without all due caution, for the effects of it are sometimes most striking. If thought necessary, pounded ice, or the cold douche, are the means the most readily obtained and used in such cases.

One of the earliest remedies should be mercury, calomel in small doses, and frequently repeated until the gums begin to be affected. Is opium to be combined with it? About this there is great diversity of opinion. By some surgeons, opium in these cases is strongly condemned; by others, it is used without scruple. I have frequently seen calomel and opium prescribed in traumatic inflammation of the brain and its membranes, by some of the most practical and best surgeons, and I must say, without any of the drawbacks, as far as I could perceive, so commonly adverted to. And opium, or, better still, morphia, is doubtless of great value in many cases presenting some of the most characteristic symptoms of inflammation. In furious delirium supervening a few days after an injury of the head, with well-marked symptoms of an inflammatory attack, calomel and morphia are of the utmost use. Of this, abundant proofs are to be found in the best authorities; and practically, I have several times witnessed the beneficial effects of these remedies in such cases.

Antimony I have always avoided. I know that it is frequently used by some surgeons of great eminence; but I have always been afraid of the vomiting which it might produce. It is an uncertain remedy in this respect, and I have often seen even a small dose produce sickness.

Are we to use blisters? Not, I think, in the first stage. Later on they often prove most beneficial, and may be applied over the head, or nape of the neck. The French surgeons, however, and especially Boyer, advocate the early use of a blistering-cap to the head. And should a blistering-cap have been thus applied, great benefit may, occasionally, be derived from the use of mercury to the blistered surface, which, in fact, is to be dressed with mercury.

In estimating any plan of treatment in cases of inflammation after injuries of the head, great care must be taken to examine thoroughly into the state of the different viscera, and especially of the kidneys. This is a point to which I have already more than once adverted; and feeling as I do, from practical experience, the absolute necessity of not overlooking this matter, again do I allude to it in this subject of traumatic inflammation.

A healthy or a diseased condition of the kidneys may not only lead us to modify our treatment, but our views of the case in hand, knowing, as we now do, how it sometimes happens that the very symptoms about the head are dependent upon the diseased condition of these viscera.

If recovery takes place after intra-cranial inflammation, the patient should be put upon his guard against running any risk of a relapse; and especially should he be cautioned about his mode of living, and his future habits for some time to come. There is, it is well known, no class of cases which require more after-care, and none in which a relapse is so apt on the slightest provocation to take place.

But notwithstanding all our endeavours, the inflammation may get ahead; symptoms of pressure follow; and then comes the question of applying the trephine.

In discussing the question of perforating the skull in contused bone, and in fractures with symptoms of intra-cranial suppuration, it was settled that the dura mater is to be divided if there are evidences of matter underneath this membrane; that is, if the dura mater, tense, and without any pulsation, bulges into the trephine-hole; and some cases were mentioned in which the patient's life had been saved by this proceeding—cases in which circumscribed suppuration had occurred within the arachnoid. But nothing was said about the treatment of abscess within the brain-substance, such abscess not being necessarily connected either with contusion of the bone or with fracture.

An abscess may form in the brain after any and every kind of injury of the head; and it is with this abscess, which may give rise to the symptoms of pressure, that we have now to deal.

In such a case it may occur that the matter in the brain is let out by simply taking away a piece of the bone, the dura mater underneath being in a sloughy condition.

Thus it happened in a case at St. George's Hospital, a few years back, under the care of Mr. Cæsar Hawkins. The trephine was applied over an exposed portion of the left parietal for well-marked symptoms of compression of the brain which had come on a month after the accident. The operation was performed under the supposition that matter would be found between the bone and the dura mater: but such was not the case; the dura mater proved to be in a sloughy state, with an opening, of the size of the thumb, through which escaped a quantity of very foul matter and brain-like substance. The man died five days after the operation; and then was found in the back part of the left hemisphere a good-sized abscess, extending down to the lateral ventricle, into which it had nearly burst.

It happens more frequently, however, that the dura mater is not in this sloughy state. One is led by the symptoms to divide this membrane, and then, finding that this affords no relief to the symptoms, is one warranted in cutting into the brain in search of an abscess? The warrant in such a difficult matter necessarily depends upon the circumstances. Should there be good reason for believing that a cerebral abscess exists under, or in the neighbourhood of, the part of the skull perforated, there is no doubt that one would be warranted in incising the brain.

Roux[*] laid open the dura mater, and finding nothing under this membrane, proceeded no further. The symptoms increased, and the patient died in a few days. Immediately under the cortical substance of the brain was a large abscess, situated a little below and behind the spot trephined. The matter might easily have been reached by a very slight cut in the brain at this part, and in such a case, with decided symptoms of compression, one may well regret that no attempt at all was made to find the matter.

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[*] Chassaignac, *Plaies de Tête*, p. 192.

J. L. Petit* was more fortunate in the issue of his case of traumatic abscess of the brain. This celebrated surgeon trepanned the head of a child, nine years old, for a compound fracture with depression. Feverish symptoms set in on the fifth or sixth day; on the following day the wound was dry, and the dura mater, of a darkish-brown colour, bulged into the trephine hole: evidently there was matter under the dura mater; this membrane was divided, and a tablespoonful of brown, fetid serosity escaped. The symptoms were not relieved by this operation, but nothing further was done. Matters went on from bad to worse, and there was but little hope left, when, on the second morning after the operation, the little fellow appeared to be much better. The improvement which had taken place was explained when the head was dressed; a large quantity of foul pus was found in the dressings, which were saturated with it, and this had come from a large abscess in the brain, which had burst during the night. The patient was quite well within two months afterwards.

It was the fortunate issue of this case which, doubtless, led M. Velpeau† to recommend delaying the incision into the brain whenever the symptoms are not very urgent. In thus delaying, M. Velpeau thinks that if matter existed in the brain, it would, in all probability, gradually push its way towards the trephine-hole, and, at any rate, render the operation less hazardous.

Dupuytren,‡ far from waiting thus, at once plunged a knife into the brain, and thereby, in all probability, saved the life of his patient. A young man was struck on the top of the head, in a brawl, with a knife, the blade of which broke in the bone, after having perforated the skull; but the exact nature of the injury was overlooked by a surgeon, who simply brought the lips of the wound together. The wound healed readily, and everything went on well for several years, save some occasional pains about the scar. This man was subsequently admitted into the Hôtel Dieu in a state of stupefaction, into which he had suddenly fallen. On examining the scar, a foreign body was clearly felt underneath it, and this, when laid bare, proved to be the point of the knife. The trephine was applied: the symptoms nevertheless continued, and paralysis of the opposite side of the body made its appearance. The dura mater was now laid open; nothing was found under this membrane; a knife was therefore plunged into the brain, and immediately a large quantity of matter flowed out. That very night all the symptoms disappeared, and the patient ultimately recovered.

Dupuytren's bold proceeding was followed by complete success. And so, too, might De la Peyronie § have been equally successful, had he been allowed to do that which he wished. A man was trepanned, and a large quantity of matter was evacuated from under the bone, with great relief to the symptoms. On the second morning, however, the symptoms were as bad as ever. De la Peyronie laid open the dura mater, and, finding nothing there, proposed cutting into the brain; but this was declined. The patient died. An abscess was found in the brain at the depth of three or four lines, and immediately underneath the opening in the skull.

And within the last few years, a surgeon‖ has been bold enough not only to make several different cuts into divers parts of the brain for a traumatic abscess, but even to lay open one of the lateral ventricles for the evacuation of matter therein contained. In this case a man, aged forty, met with a severe compound fracture of the skull, and ultimately lost several pieces of the frontal bone. He did well, but five weeks after the removal of the bone, cerebral symptoms made their appearance. The scar was laid open, and three more pieces of loose bone were taken away. The symptoms still persisting, Dr. Detmold was led to think that there was an abscess in the brain. The scar was now dissected off, with the portion of the dura mater to which it was attached; an incision an inch long and half an inch deep was then made into the brain-substance, and a thick stream of healthy pus flowed out. The symptoms were at once relieved, and the patient progressed most satisfactorily until hernia cerebri occurred. This was kept down by pressure; and on the eighteenth day after the opening of the abscess, the patient was about, a hole through which a probe could be passed into a cavity in the anterior lobe of the brain still remaining. Three weeks afterwards, although he felt very well, this man began to lose his memory; he even forgot his own name, and could no longer read nor write. The parts involved in the injury became hot and swollen, and stupor reappeared. A fresh incision was made through the integuments into the brain, but this time no matter followed; the symptoms, however, appeared to be greatly relieved. Dr. Detmold probed the wound, and found that the instrument passed four inches and a half into the brain towards the lateral ventricle, into which it was thought that the abscess had burst. The patient continued to mend for a time, but five days afterwards he became speechless. It was then thought advisable to explore for more matter; and seven weeks after the first incision, another one, an inch and a half deep, was made into the brain, and a probe passed in nearly five inches. Shortly after, matter flowed freely through the wound. The patient sank the same evening. Both ventricles contained a large quantity of thin pus, and at the anterior corner of the roof of the left one there was the last incision. The brain itself was vascular, and nothing more.

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* *Mal. Chir.* t. i. p. 91.

† *Plaies de Tête,* 1834, p. 87.

‡ *Bless. par Armes de Guerre,* t. ii. p. 146.

§ Sabatier, *Méd. Opér.* 1832, t. ii. p. 65.

‖ *Amer. Jour. of Med. Sc.* N. S., No. 37, p. 86.

There are many bold deeds in the records of surgery appertaining to injuries of the head, but Dr. Detmold's must be classed amongst the boldest. The first incision certainly saved the man from impending death; and, in the state that he was subsequently in, it might be argued that he was none the worse off for the other incisions, which offered him the only chance of safety, if chance of safety there was. Few surgeons will, however, be found to follow Dr. Detmold's example.

PRESCOTT HEWETT.

INJURIES OF THE BACK.

Provisions in the Structure of Spine against Common Injuries.

ACCIDENTS to the vertebral column derive their chief importance from endangering the spinal cord. It may assist in enabling us to estimate the comparative liability of different parts of the spine to be injured and the relative severity of the effects in the various kinds of violence to which it is exposed, if we take a general survey of its structure and uses, before entering on the proper subject of this essay.

The spine serves several distinct offices in the skeleton; some of which appear, at first, incompatible with others. It is a pillar for sustaining weight, a girder for connecting distant members, an elastic-jointed mechanism for motion, a supporter of the ribs for breathing, and a tube for containing the most vitally important organ next to the brain, the medulla spinalis. The safety of the spinal cord is secured in various ways. Being lodged in the centre of the column, it occupies neutral ground in respect to forces which might cause fracture. For it is a law of mechanics that when a beam, as of timber, is exposed to breakage, and the force does not exceed the limits of the strength of the material, one division resists compression, another laceration of its particles, while the third, between the two, is in a negative condition. Applying this principle to the vertebral column, it will presently be seen that the violence which leads to fracture is in the majority of cases directed so as to bend it forward. Consequently, the anterior segment will be subject to compression, the posterior to laceration, and the intermediate will be in a neutral state. Now, the fore part of the spine, by the peculiar structure of the bodies and intervertebral cartilages, is admirably calculated to resist the effects of undue pressure; the back part, by the arrangement of its numerous fibrous and elastic ligaments, is equally adapted to resist the effects of a rending force; and the spinal cord, situated between the two, occupies the place of least danger. Again, the cord is specially guarded by the elasticity and nicely-graduated flexibility of the column. As each vertebra meets the next below at three distinct surfaces of contact—the body, and two articular processes—it follows that, when the superincumbent weight falls upon it, the pressure is distributed through these different lines of support. In the bodies, the force will be broken by the intervertebral cartilages acting as buffers; in the articular processes, which are wedge-shaped, and articulated with the thin edge of one pointing to the base of the other, it will be gradually lessened by the broader portions of both, approximating in proportion to the compression. The mutual interlocking of the adjoining vertebræ, caused chiefly by the ascending articular processes being overlapped from behind, and the descending from the front, has the effect of limiting the motion of any two or three vertebræ within a small sphere, but does not prevent a considerable range in several. There being various grades of flexibility in the different regions of the spine, certain curves are introduced near the respective junctions, to equalise the movements; for, as the force directed on any part must impinge on a series of oblique surfaces, when travelling along these curves, it will be transmitted from one vertebra to another, with gradually diminishing impulse, till exhausted. Another provision for the safety of the spinal cord is seen in the way in which it is attached with its membranes to the interior of the vertebral canal. The cord is small compared to the area of the canal; hence, instead of the theca being in close contact with the osseous surface, as the dura mater is with the cranium, it is separate, except at the foramen magnum. The whole way down the canal, the theca is tacked at intervals to the sides, by those processes which it sends off to enclose the spinal nerves, as they emerge at the intervertebral foramina. Within, the visceral arachnoid membrane is so far apart from the pia mater, which invests the cord closely, that a layer of subarachnoid fluid of considerable thickness intervenes, and surrounds the cord. Thus the medulla floats, as it were, on a water-bed: that bed being hung within the canal by cords, much in the same manner as a sailor slings his hammock in his cabin. The last example that may be adduced of a special arrangement in the structure for averting danger from the cord is suggested by observing the mode of its termination within the vertebral canal. In quadrupeds and even in man during fœtal life, the cord is continued along the whole course of the canal to the sacrum. But in adult man the cord begins to diminish in size at the last dorsal vertebra; it then tapers to a point, and ends opposite the second lumbar vertebra. For the last three inches, it is covered so thickly by the roots of the lumbar and sacral nerves as to be concealed from view. Below the part where the cord terminates, the canal is occupied only by the cauda equina, composed of a leash of long, firm, flexible roots of nerves, together with the theca and other investing membranes. It appears that that curtailing of the cord has relation to the more violent, and as they may be regarded in reference to it, unsafe movements performed at the lumbar region in man compared to quadrupeds. The sudden bendings, twistings, and joltings incident to the base of a flexible column, which rests on a comparatively solid foundation, the pelvis, and which from being upright has the whole superincumbent weight concentrated upon it, are somewhat moderated by the elasticity of the region, as well as by the large sweeping arch formed by the vertebræ there—a curve that may be likened not inaptly to the C-spring of a carriage; yet it may be admitted that shocks which would be harmless to a bundle of roots of nerves like those forming the cauda equina, might be destructive of the functions of an organ of such soft consistence as the spinal cord, had it been prolonged the whole way to the sacrum.

Weakest parts of the spine.—Observation has shown that certain portions of the column are more frequently the seats of injury than others. Commencing from below, the parts referred to are, 1, the dorsi-lumbar; 2, the cervico-dorsal; 3, the atlo-axial regions. It thence appears that the portions most prone to injury are those situated where a flexible joins on to a comparatively inflexible division. And it might be expected that such should be the case. A force directed upon a pliant part of the column will cause it to bend, but on reaching a more rigid part, it will fail to do so; instead, therefore, of meeting with a gradually yielding, it will encounter a dead resistance; the force will be concentrated in place of divided, and it will overcome the strength of the material. Sir C. Bell illustrated the point by the breaking of a fishing-rod. If the trout-fisher in casting a long line snaps his rod in twain, the fracture will take place, not in the centre of one of the pieces, but near a joint—that is, at a part analogous to where the spine is most liable to be broken.

SPRAINS.

The whole number of joints in the spine is little short of eighty; each articulation being provided with its complement of ligaments. Besides these proper ligaments, others pass from vertebra to vertebra, at numerous different points; among which the ligamenta subflava are particularly noted for their elasticity and strength. When the column is subjected to a violent bend or twist, the force comes chiefly on these joints, and their cordages: but it may reach also the intermuscular septa, fasciæ, and tendinous expansions of the muscles. If not sufficiently strong to withstand the violence, the fibres composing them will be overstretched and torn, sprained, or ruptured.

Sprains in the spine will present some diversities of character, according to the part of the column in which the force is concentrated. If it fall principally on the dorsal region, characterised by rigidity of structure, the injury will be of the nature of a jar or jolt, affecting a particular point; if it be directed either on the cervical or lumbar region, which are remarkable for their mobility and elasticity, the impulse will be broken and dispersed, and the injury more general.

Again, in reference to the cervical region, it is to be noticed that sprains are liable to take place in it from a special cause. Owing to the skull being articulated at its base, near the middle, on the summit of this portion of the column, imaginary lines drawn from the point of junction to the farthest convexities of the skull along its periphery, will represent levers, which will act on the axis of motion in the cervical vertebræ, with power commensurate to their different lengths. For example, if a man falling headlong lights on the parietal convexity of one side, the portion of skull intervening between that eminence and the occipito-atlantal articulation, will be like a lever, which will propagate the force with increased power to the cervical vertebræ.

Cases of Sprains of the Neck.—The writer has lately had under his care three cases of sprain of the neck, occurring successively within a short period. As they illustrate varieties in the accident, the details may be briefly given. In two of them, symptoms of the spinal cord having been involved were present for a short time.

1. A young man, in a carpenter's workshop, was stepping backwards, when he tripped on a heap of planks, and fell on his back. His shoulders were received on the planks, but his neck and head passed beyond them; the head consequently descended with a sudden impulse towards the floor, and by that means the neck underwent an abrupt bend backwards. Swelling at the back of the neck, from the occiput to the scapulæ, so great as to be visible at a distance, took place soon after the accident. He was unable to keep his head erect; and before attempting to do so, placed a hand on each side to steady it. In twelve days, he began to sit partly up in bed, to take his meals. At the expiration of a month, having been provided with an artificial support, he was well enough to be made an out-patient.

2. A man, aged thirty-one, while engaged in amusing his infant, on the floor, and stooping on his hands and feet, was springing forward, when he tripped and rolled over, with his head under him. The weight of his body came with an impulse on his neck, and gave him much pain from the twist it caused. He lay motionless, flat on his back, for ten minutes. When he attempted to move either his arms or legs, he found himself unable: and he had a sense of numbness, and of pricking, throughout the body. His legs gave way under him, as if he were intoxicated, in trying to stand. On being brought to the hospital, it was necessary to carry him into the ward. When lying on the bed, he moved both upper and lower extremities, but in a feeble, or forced manner. Sensation was not lost, only impaired; he was able to tell correctly what parts of his body or limbs were touched. Within twelve hours, both motor power and sensation were restored; and the paralytic symptoms did not afterwards return. He complained of acute pain in the neck, which was aggravated by the slightest motion of the head; and he therefore kept the head perfectly still. He lay in bed, with his neck sunk on a low soft pillow, propped around with sand-bags. On examining the neck, the chief tenderness was at the site of the fourth cervical vertebra; and there deeply-seated swelling could be perceived. The treatment consisted principally in the enforcement of absolute rest for the neck; with the application of the tincture of iodine. A plastic shield, or support, reaching from the shoulders to the back of the head, having been prepared, he was allowed in a month to leave his bed. He could then perform the nodding, but not the rotatory, motions of the neck; when trying the latter, he turned his whole body round. In nine weeks, the movements of the neck seemed to be quite restored; but he was kept in the hospital, for precaution's sake, three weeks longer. He returned to his occupation, that of a shoemaker, and called several times subsequently to show that he was well.

3. A little girl, three years old, of slightly ricketty conformation, with large head, was admitted into the hospital, late one evening, with paralysis of the upper and lower extremities. She had fallen that morning out of bed, head foremost, and was insensible for a few minutes. During the day, it was remarked that she did not get upon her feet, or move her legs; and that she did not use her hands, as in feeding herself. When examined, motor power was observed to be lost in both upper and lower extremities. She showed no signs of pain when the skin was pricked anywhere below the upper part of the chest. Reflex movements were excited in the lower extremities when the skin of the abdomen, and it alone, was pricked; and then the child

gave a slight cry of pain. Respiration was natural. Neither bladder nor rectum was affected. When the head was lifted from the pillow, for the purpose of examining the neck, the child uttered cries, both, as it appeared, from the pressure of the fingers at the back of the neck, and the movement; during the proceeding, she held the head in a stiff, constrained position, and after it, seemed pleased to keep the head at perfect rest on the pillow. For three days, no perceptible change was observed in the child's condition. On the fourth, there were visible signs of improvement. On the fifth day, it was discovered that she could freely move both upper and lower extremities, and motion of the head had ceased to give her pain. The mother, who had been allowed to stay in the hospital, being impatient to return home, took the child with her, in spite of the representations made to her of the danger. But she brought the child repeatedly afterwards to be seen, and she remained quite well.

Sprains in the loins.—Sprains of the spine are more frequent in the lumbar region than elsewhere. They are generally caused by forces which bend the column downward and forward in excess. An ordinary example is that of a person falling from a height, and alighting on his nates. Owing to the body of the individual, in such a case, descending with uniformly accelerated velocity, it follows that, if the height be great, the momentum will very much increase before he reaches the ground; when he arrives there, the descent is suddenly interrupted by the contact of the nates with the ground, but as the power of inertia continues in force in the upper part of his frame, and is restrained only by the spine, that upper part descends, and expends all its momentum on the column; hence the cervical and dorsal regions, and the load with which they are weighted, fall down towards the pelvis, the body is doubled up, and a violent strain is caused on the joints of the lumbar vertebræ. A bricklayer, recklessly, and for a wager, took a leap from the top of a four-storied house, on to a heap of loose sand on the ground. He came down on his buttocks, and was found to have sustained a severe sprain in the loins. In a moderately short time he recovered from the effects of his foolhardiness. Or the loins may be sprained by a heavy weight falling on the upper part of the body, while the lower limbs are fixed: the spine is then in the position of a long lever, with the fulcrum situated at the junction of its base with the pelvis; the superadded superincumbent burden represents the force acting on the lever, and the power thus mechanically generated is centred chiefly in the loins. The direction in which the spine is thrown is generally downward and forward; hence the structures on the fore part—the bodies of the vertebræ and intervertebral substances—suffer compression; those on the back undergo elongation and overstretching.

Considerable tumefaction across the region of the loins soon follows accidents such as have been described. Ecchymosis may or may not be combined with the swelling. Sometimes discoloration does not appear for several days. The line of the spinous processes is found, on tracing them, to be normally straight, and their surfaces level. Pain on pressure, instead of being limited to the processes of one or two vertebræ, which would raise the suspicion of fracture, is the same throughout many adjoining ones equally. With difficulty, and much exhibition of weakness and pain in the loins, the patient will make an effort to hold the spine erect, and if he succeeds, and no deformity be presented, it may be assumed confidently that the injury consists only in a sprain. The posture he will prefer in bed will be that of lying on one side, with his body semi-flexed, and he will be reluctant for many days to make the slightest change in his position—any slight movement exciting fugitive spasms in the lumbar muscles, analogous to those in a fractured leg. The chief criterion of his getting better is that he moves himself about in bed of his own accord. It commonly takes from four to six weeks' confinement in the recumbent position for recovery to be effected. The treatment does not differ essentially from what is followed in sprains of the joints generally. A mercurial purge may be administered at first, the diet kept low, and an occasional dose of Dover's powder be taken at night. For local applications, priority may be given to poppy fomentations; or, either as a substitute or successor, cotton wool may be steeped and then wrung partly dry, in a lotion of lead and opium, or of arnica; when teased out, it may be laid in a thick layer, widely over the loins; if covered first with oil-silk or gutta percha, and then with dry flannel, the wool will retain its moisture and warmth for a long time without change, and be an efficient and agreeable application. At a later stage preference may be given to a lotion containing sal-ammoniac. When the swelling has been dispersed, and induration remains, mercurial liniment or tincture of iodine may be advantageously used. It will be proper to provide the patient, when about to leave his bed, with a riding belt stiffened by additional whalebone.

Hœmaturia, from sprain.—In cases of sprain occurring at the lumbar region, it is not uncommon for the patient to pass blood with the urine for several days after the accident. From this it may be inferred that one, or perhaps both kidneys have been injured, so that a breach of surface has been produced. When the situation of these glands in relation to the spine is considered, it need not surprise us that a complication such as hæmaturia should be met with. The kidneys lie in close contiguity to the spine at the part where the flexion of the column, on the occasion of sprain taking place, is most acute. And they are fixed to the place they occupy with comparative firmness: so as to be incapable, like the floating viscera, of evading injury. It is also to be borne in mind that, when the spine is violently bent, in the production of sprain, the flexion, at the moment, is much greater than observation could enable us to discern; for owing to the elasticity of the column, it follows that, as soon as the compressing force ceases to act, it recovers its form, by its resilience. The writer cannot refer to the evidence of post-mortem examinations for stating at what particular part of the gland, the lesion from which the blood is derived is situated; but it may be conjectured that it is somewhere in the hilum. In that case, the blood will flow directly into the pelvis, and thence, along the ureter, into the bladder. The amount lost varies in different cases. Clots are occasionally formed in the bladder, requiring the injection of warm water for breaking them down. In general, the discoloration of the urine is high—deep red, or brown—only for one or two days; on the third or fourth day, the colour may be clear and florid; and in a day or two more, or even in a shorter time, the water may be of its natural appearance.

Rarely is the quantity of blood lost so great as to excite alarm; yet in a case lately witnessed by the writer, apprehensions were for some days felt that the patient, a young man, would not recover. The sprain had not been severe: the bleeding was uninterrupted, and unusually profuse during the first four days; it nearly ceased for two days; then it returned, and lasted with its former profusion for two days. A cessation for a day now took place; on the following day, the tenth, it reappeared in great quantity; but it then stopped finally, the patient having become blanched and excessively weak.

When such an important gland as the kidney had been crushed and broken, to such an extent that hæmorrhage goes on from a rent in it for several days, it might be thought probable that the damage would be followed by ulterior bad results, especially that inflammation—nephritis—would ensue. But extensive observation negatives that view: general experience shows that when patients recover from the immediate effects of hæmaturia brought on by sprain of the spine, they are not more prone than others to renal complaints.*

It is here to be remarked that, if the kidneys be previously diseased, hæmaturia may occur from a comparatively slight injury. That is well known in reference to cases in which calculi have formed in the kidneys. The remark applies also to the congested condition of the gland in the early stage of albuminuria, of which the following case is an illustration.

The writer was witness in a trial in which a gentleman claimed compensation from a railway company, for being affected with Bright's disease, in consequence of an injury to his back received in a collision on their line. The injury consisted in a bruise over the right ilium, and side of the loins. As he walked some distance for his pleasure, and took a long journey immediately afterwards, it may be inferred that the contusion was not severe. On the following day, he observed blood mixed with his urine; and he continued for four more days to pass blood. On examining the urine at that time, his medical attendants found albumen contained in it; and they particularly stated, that the quantity of albumen was larger in proportion than could be accounted for by the presence of the blood. During the whole period from the date of the accident to that of the trial, eleven months, the urine was found to contain albumen. And the view contended for by the witnesses in his favour was--that albuminuria had been caused by injury inflicted on the right kidney, in the collision. On the part of the railway company, it was ascertained that previously to the accident the gentleman had been subject to eczema; and that, shortly before it, he had been cured under treatment. Accordingly, the medical witnesses on that side (the writer being one), argued that albuminuria was known to follow eczema, on its being cured; and for that, and other reasons which need not be stated, they expressed a strong opinion that the plaintiff was suffering from the disease when he met with the accident, and that the injury could not have brought it on. The jury, nevertheless, awarded heavy damages to the sufferer.†

Sprains; hæmorrhage in vertebral canal; paralysis.—Sprains of the spine have hitherto been considered only in reference to their effects on the joints, apart from the spinal cord. It is now proposed to attend to a class of the same injuries, in which blood becomes extravasated in the vertebral canal, the spinal cord is compressed, and paralysis ensues. The following case will serve to illustrate and introduce the subject.

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* In his Lectures delivered at the College of Surgeons, M. Le Gros Clark makes the following remark, regarding hæmaturia, as it occurs in connection with injuries of the spine: 'Of the many cases I have witnessed, I have never had reason to suspect that nephritis or organic disease followed.' *Brit. Med. Journ.*, October 3, 1868.

† A somewhat similar case was reported briefly in the *Times*. A woman had been bruised in the loins, from the falling in of the roof of her dwelling. She claimed compensation for the injury, from her landlord. The medical witnesses on her side gave evidence to the effect that she was seriously ill from Bright's disease, and that the disease was the result of the accident she had sustained.

A female, aged sixty, was admitted into the Middlesex Hospital under the writer's care, in March, 1841. She had fallen down a flight of steps shortly before. Her back was the part principally injured; but no irregularity in the line of the spine could be perceived; and although she sat up for examination, there was no particular part at which she felt greater weakness than in others. Both upper extremities, and the right lower extremity, were deprived of voluntary motion. Sensation, however, was nearly perfect in these members; she spoke only of a little numbness in them. Reflex movements could not be excited in the upper extremities; but they were particularly lively in the paralysed lower extremity. Very slight causes brought them on. For example, if she spoke loudly, or if she sneezed, the leg would spring up; bending the knee, and tossing the bed-clothes up. And she was evidently alarmed at these unaccustomed movements. Being of a quick temper, and especially grieved at her hands not obeying her will, she not unfrequently gave way to violent passion; on these occasions, she would shake her head vehemently, and utter lamentations at the top of her voice; whilst thus exclaiming, the leg, over which she had no control, would suddenly jump up, and that instantly silenced her. The rolling of the head here adverted to, was an additional proof that the bones and articulations of the upper part, at least, of the spine, were not seriously injured. The breathing was not disturbed, as might be inferred from the loudness of her voice referred to. At first, she had retention of urine; and for a few days, incontinence; but she soon afterwards had natural control over the bladder. The action of the bowels was regular. During the first ten days, no perceptible change took place; but in the following fortnight, a slow and gradual increase of power over the paralysed limbs was observed. After that, all progress seemed to cease. There being no weakness or pain in the spine to interfere with getting up, she did not remain long confined to bed, and soon made attempts to walk. In these, it was necessary that she should be assisted by a nurse on each side; as owing to the paralysis of the arms, she was unable to use crutches. Each time the paralysed (right) leg was lifted from the ground and advanced, it described a gyration in the air; and it was too weak for her to bear her weight upon it. The way in which the muscles of the upper extremities regained some of their power was peculiar; being different in each. On the right side, the muscles of the upper arm became stronger, but no improvement took place in those of the forearm; it was the converse on the left side: the muscles of the forearm became stronger, but no improvement took place in those of the upper arm. Consequently, on the right side, the patient was able to bend and extend the arm at the elbow, but she was unable to hold anything in her hand; while on the left side, she was able to close the fingers and hold an object, but she could not bend and extend the arm at the elbow. Accordingly, she contrived to make the one supply the wants of the other. Thus, when she wished to take anything into the left hand, she employed the right arm to lift it to a proper level, or to guide it according to her wishes. She was kept in the hospital for three months, long after every hope of amendment had been abandoned. The subsequent history of the case is not known.

In seeking to account for the paralysis in the above case, the idea of its having been caused by fracture or dislocation of the spine, may be dismissed. Had either given rise to it, the patient could not have sat upright; there would have been irregularity in the line of the spine; the paralysis would have included both lower extremities; and motor power and sensation would probably have been lost conjointly.

The next view is, that a blood-vessel had been ruptured by the violence; and that blood had been extravasated into the vertebral canal, compressing the spinal cord, and partially depriving it of its functions.

That, in this case, the blood which escaped had been poured into the loose space intervening between the osseous walls of the canal and the theca spinalis, seems most probable; and also, that the source of the blood was the venous sinuses, which line the interior of the canal in the form of plexuses. It is to be noted that in these capacious sinuses there are no valves; and that if one branch of the plexuses be ruptured, the blood will flow unobstructed from all indiscriminately. It is likewise to be observed that the sinuses are subject to the influences of the acts of respiration: they will be nearly empty, in inspiration; but over-distended and ready to burst in expiration. When a person, therefore, meets with an accident, such as that of falling downstairs, and some part of the spine, most likely the cervical, is inordinately bent or twisted, it may be understood that a particular branch of the venous plexuses lying in close proximity to the bony surface of the vertebral canal, where the flexion is most acute, will be liable to be squeezed and torn. Again, owing to the bend of the neck referred to, together with a doubling up of the body, and compression of the chest in the fall, the breathing will be interrupted, or the act will be that of expiration; and as it is during expiration that the venous sinuses become overfilled with blood, and their coats overstretched, it may be understood that the danger of rupture taking place will be increased from that cause.

As the paralysis was partial, three alone out of the four extremities being affected, and motor power being the only property lost, it may be inferred that, if blood extravasated external to the theca were the compressing agent, it had been collected in the canal in unequal quantities at different parts. Such an hypothesis would explain how one of the lower extremities escaped being deprived of its motor power: for it may be supposed that a smaller quantity of blood had been deposited at the part of the cord with which the nerves of that extremity communicate than elsewhere. In regard to the other point, namely, that sensation was preserved while motion was lost, it is a fact generally observed in affections of the spinal cord, that motor power is frequently destroyed while sensation is not affected. No more frequent example can be referred to than the paralysis which attends caries of the vertebræ; for in these cases sensation is rarely lost. And the difference, it would appear, depends on the seat of sensation in the cord being placed more deeply and securely than that of motion; so that a compressing force, or morbid influence, reaches the latter sooner than the former. Hence it may be understood, that if in this case a clot of blood were the cause of the compression, the power of motion might be lost, independently of sensation.

In the narrative it is stated that little or no amendment in the paralytic symptoms was observed during the first ten days, that in the following fortnight the affected limbs increased perceptibly in strength, but that afterwards improvement ceased. These phenomena may be explained on the supposition that the blood in contact with the spinal sheath did not undergo, for some time, any material change; that absorption of the fluid constituents of the blood somewhat later took place; and that then, from the cord being partly relieved of compression, there was a proportionate addition to the strength; but that, at last, no further reduction in the size of the clots could be effected—that the coagula, at one time like jelly, had become indurated and adherent.

A question in connection with these cases of intravertebral hæmorrhage originating in injury, of great interest, but difficult to answer, is this: Can it be ascertained during life, from appropriate symptoms, whether the effused blood has been derived from a torn vessel without or within the theca—that is, whether the blood is situated outside or inside the sheath of the cord? In the case just related it has been considered that the extravasated blood was situated between the theca and the osseous wall of the canal; but as there was no post-mortem examination to verify the opinion, the conclusion must be taken as uncertain. And the difficulty of replying to the question arises from the circumstance here indicated, the dearth of well-observed cases completed by including an account of the appearances after death.

In treating of the subject, M. Le Gros Clark says: 'Extravasation of blood within the theca vertebralis may occur without fracture; but such instances affording an opportunity of verifying the actual condition are rare. I have a memorandum of a remarkable case of this kind, which was narrated to me, but which I did not see. A man was struck violently on the back with a chain-cable; there were no immediate symptoms of spinal injury, but a paraplegic condition soon supervened, extending rapidly upwards, and destroying life by asphyxia. The theca was found distended with fluid blood, derived from a ruptured spinal artery.' He refers to another case: 'A man was injured in a collision in the tunnel, four or five miles from Brighton. He walked this distance with some difficulty into the town, and within twenty hours became entirely paraplegic. He recovered slowly; and after a lapse of two years, was able to walk as well as before the accident. One spot on the back was always tender, and continued so still at times. The analogy between this case, and the similar but fatal injury which I have already mentioned, seems to point to hæmorrhage as the probable cause of the protracted symptoms.'*

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* Lectures at the College of Surgeons, reported in *Brit. Med. Journ.*, October 3, 1868.

In the *London Hospital Reports* two cases are related, with interesting details, of incomplete paraplegia from injury of the spine, in both of which the patients recovered. As the men were able to sit up, and attempt to walk, each within a few days from the accident, it may be inferred that there was no breach in the vertebral column in either: and that the symptoms depended on intravertebral hæmorrhage. Vol. iii. pp. 334, 336.

Inflammation of joints of the spine from sprain.—One of the dangers to be apprehended from a sprain in the spine is that inflammation will spread from the joints, the first recipients of the injury, to the adjacent structures, and thus involve the spinal cord.

The observations about to be made do not apply to caries of the vertebræ; a disease in which the cord is frequently included, and paraplegia the result. Patients who have that complaint, or their friends, generally attribute its commencement to a fall or blow on the back. But when the history is properly investigated, it is commonly made out satisfactorily that the morbid process had begun before the accident, and that the injury only aggravated and made apparent a latent disease. See DISEASES OF THE SPINE.

The subject now entered on is not altogether easy to treat. And a principal difficulty arises from the circumstance that in accidents which are apparently alike, the events are greatly varied. Thus it has been already seen that, in sprains of an apparently alarming severity, in which it was evident from the symptoms that the cord had participated in the injury, none of the serious results which might have been expected followed (Case 2, p. 359). On the other hand, cases may be met with occasionally, in which the original violence has been comparatively slight, and disastrous consequences have unexpectedly ensued.

The joints implicated in a sprain are liable to be affected with chronic inflammation, and what is then chiefly to be apprehended is, that the products will gain access to the vertebral canal, and so lead to destruction of the functions of the spinal cord. In connection with this, it may be noted that an important distinction exists between the relation of the dura mater of the brain to the cranium, as contrasted with the relation of the theca or dura mater, of the spinal cord, to the inside of the vertebral canal. In the former, the membrane being firmly adherent to the bone, serves the purpose of periosteum: whence, if the cranium be injured or diseased, the dura mater will become inflamed, and that inflammation will extend immediately to the brain. But in the latter, the bony structures of the walls of the canal have a distinct and appropriate periosteum; the dura mater investing the cord is at a remote distance from them. Consequently there is not the same danger of inflammation, set up in the parietes of the canal, spreading to the cord, as in the case of the brain.

When joints of the spine that have been damaged by sprain are attacked by chronic inflammation, they are liable to follow a course, first, of gradual swelling and induration, and then of indolent suppuration, like what takes place in other joints. The earliest symptoms in these cases of nerve affections may be partial paralysis, depending on some of the spinal nerves, which come out from the canal at the seat of disease, and are involved in their passage through the intervertebral foramen in the abscess, being deprived of their functions. Later, the paralysis may be more general, including the lower and perhaps also the upper extremities, thereby showing that the cord has become compressed by intrusion of a portion of the abscess into the vertebral canal; in these circumstances irregularities and inequalities in regard to the functions lost or retained in the afflicted limbs, will be observed. At this stage, when chronic abscesses surround the diseased vertebræ, and there is accompanying paralysis, the question may arise whether the case be not one of caries of the spine. Doubt on that point will be removed when it is perceived that there is an absence of angular deformity at the seat of disease. In caries of the vertebræ, it is invariably the bodies and intervertebral substances which are destroyed; and as the destruction of these parts is in fact an undermining of the superior portion of the pillar, that portion necessarily falls forward. By so doing a prominent bend in the line of the spinous processes is produced, but such an angle is not formed, however much the lateral articulations are destroyed. When the abscesses break, and continue discharging pus, the prognosis is unfavourable. But if they be arrested while immature, anchylosis of the diseased articulations may take place; absolute rest will then be gained; resolution of the abscesses may be effected, and from compression on the cord being removed, its functions may be restored, and the patient will recover.*

Latent breach of spine from sprain; suppuration in canal; subsequent paralysis.—This is not an unfit place to introduce a notice of certain injuries of the cervical region of the spine, which may be considered as exaggerated examples of sprain. They are distinguished by a breach having occurred in the column, and on that account they might be treated in connection with fractures. But the violence causing the breach resembles that by which sprain is produced; the vertebræ by their elasticity recover their places, the injured part can still support the weight of the head erect: paralysis occurs, not, however, from the direct effects of the original injury—it supervenes, several days after the accident, from suppuration in the canal, the consequence of the lesion.

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* An interesting case of partial paralysis, arising from injury to the cervical vertebræ, and presenting numerous different phases in its course, is related under the head of *Twists of the Spine,* by Mr. Erichsen. It appears from the account of the condition of the neck, and from the symptoms, to have been a case of the kind described in the text. The patient recovered. On *Railway Injuries*: by John E. Erichsen, p. 86.

The breach may be presented in two different forms: either as the effect of a rupture of the connecting ligaments of two adjoining vertebræ, in which the articulating surfaces have first been divorced, and then have settled down again into their places; or, as a horizontal fissure across the middle of one of the vertebræ. In both instances it may be understood that, when the disrupted portions have come back into apposition, they will be retained *in situ* by the surrounding muscles.

A case which illustrates the first kind of accident has been recorded by Sir C. Bell. A man fell from the shaft of his waggon, and pitched on the back of his neck and shoulders, where swelling and discoloration soon afterwards appeared. He complained of stiffness in the back of his neck; on account of which, leeches were applied. On the eighth day, he was seized with a succession of convulsions, which lasted twelve hours; and the struggles in his delirium were so violent that it required two men to hold him. The delirium continued with interruptions. On the twelfth day, he lost power over one arm; two days later, he was paralysed in the lower extremities, but he regained the command over the arm; on the eighteenth sensation returned in the lower extremities; on the following day, he died. It was discovered, on dissection, that there was a loosening of the connections of the seventh cervical vertebra with the first dorsal; and between them there was a considerable space, the intervertebral substance having been destroyed. On cutting the muscles at the side of the last cervical vertebra, a little pus oozed out from between the bones. Within the spinal canal, pus was found to have dropped down through the whole length of the sheath, to the cauda equina. Outside the spine, pus lay under the scapulæ; in front, it was bounded by the œsophagus.*

Mr. Simon has furnished a case which illustrates the second form of the injury. It is given under the title, 'Latent Fracture of the Spine proving fatal by Suppuration, within the Vertebral Canal.' The details are briefly these. A girl, in the dark, fell down an embankment, twelve feet high, and injured her neck. She afterwards walked three miles. For eleven days she continued at her occupation. On the fifteenth, she applied for admission into St. Thomas's Hospital, on account of severe pain in her neck. No irregularity in the spine could be detected. There was no anæsthesia or paralysis. Her complaints of pain and tenderness were vague: she spoke chiefly of suffering between the shoulders; and turning round into the prone position in bed was done slowly, stiffly, and with cries. Early on the following day she complained of numbness and twitching in her limbs, especially the lower; and in the evening, voluntary motion was quite lost in the legs, and almost in the arms; sensation also was very much impaired in both. High fever, with delirium and tympanitic distension of the abdomen, accompanied the last-mentioned symptoms. She died on the third day after admission, or eighteenth after the fall.

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* *Surgical Observations*, p. 145.

'On examination thirty hours after death, a horizontal line of fracture was found traversing the body of the seventh cervical vertebra, just above its inferior surface. Beyond a very little gaping in front, which would allow the edge of a scalpel to be insinuated flatly between the fragments, there was not the slightest displacement; and the posterior common ligament was untorn. The vertebral canal contained between its osseous walls and the dura mater a large quantity of pus, which, from two inches below the foramen magnum, descended the whole length of the cord. At the several intervertebral holes, it had crept somewhat along the issuing nerve-sheaths, and between the first and second dorsal vertebra had actually emerged, following the subdivision of the first dorsal nerve, so as to spread among exterior parts. These burrowings of matter were cut into before the canal was opened. . . . The outer surface of the dura mater was roughened by inflammatory deposits; but none were found within it; nor was there any softening, or microscopical change in the structure of the spinal cord. No other disease was discovered in the body.'*

Concussion of the spinal cord.—High authority sanctions the use of the term 'concussion' of the spinal cord, to indicate an injury of the back, followed by paraplegia.†

The word is intended to express a certain effect produced upon the cord by violence, which reaches it directly. The injuries that have hitherto engaged our attention have arrived at the cord indirectly; that is, the functions have been destroyed or impaired through injuries which have originated in structures adjoining, but external to, the spinal sheath. In concussion, the inmost recess is penetrated at once, and the organic changes connected with the cord commence and finish within the sheath. That sheath, continuous with the cerebral dura mater, forms along with it the boundary of the large cavity that contains both brain and spinal cord. Accordingly, there is this difference between the first class of injuries and concussion, namely: that in the former the sheath or dura mater of the spine forms a defensive barrier, more or less effectual, between the primarily-injured structures and the cavity common to the brain and cord; while in concussion, the morbid processes are conducted from first to last in the interior of that cavity.

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* *Trans. Pathol. Soc.* vol. vi., p. 42.

Further on, a case will be noticed in which the atlas had been fractured transversely near its middle, and in which the anterior segment, including the articular surfaces in relation to the occiput and the atlas, and carrying off with it the processus dentatus of the axis, had been dislocated extensively forward; no suppuration, and no paralysis followed: the patient lived about a twelvemonth. During life, the nature of the injury was unsuspected; it might well have been taken for sprain.

† *Treatise on Dislocations and Fractures*; by Sir A. Cooper; edited by Mr. B. Cooper, p. 526.

'Concussion of the spine,' often used, is objectionable as a title. We do not speak of concussion of the skull.

The term 'concussion,' as applied to the spinal cord, has obviously been derived from a supposed analogy between the injuries occurring to it and to its kindred organ the brain. When a man's skull is beaten in and a fragment is depressed, or when a torn artery throws out blood which coagulates and produces pressure on the brain, paralysis of one side of the body ensues: the surgeon elevates the depressed fragment, or exposes and washes away the coagulum, and forthwith, in favourable cases, the paralysis disappears. So when the spine is fractured, and displacement of the fragments takes place, the end of one of the portions presses upon the cord, and it is conceived that the paraplegia resulting from the accident must be owing to that compression. But certain cases of injury of the back are met with in which paraplegia has directly or shortly afterwards occurred, and in which, upon examination of the spine after death, no fracture, displacement, extravasated blood, or anything capable of compressing the cord, can be discovered. The explanation therefore given is, that the spinal cord had been damaged by concussion.

The following case has been just recently reported in one of the journals.

> A man fell from a railway van, and lighted on his head and shoulders. Instant paralysis of both upper and lower extremities was the consequence; and the breathing was diaphragmatic. He lived only for about sixty hours. On examination, neither fracture nor dislocation was found in any part of the spine; nor was blood effused in the canal. But on making a section of the cord, opposite the third and fourth cervical vertebræ, a clot of blood was found lying in its centre.*

From the remarks appended to the case by the narrator, it is obvious that he had no doubt of its having been a case of concussion, and it would seem that the same opinion would be held generally. But it is evident that the lesion in the cord admitted of being satisfactorily accounted for otherwise. It does not appear improbable that a sudden, violent, and extreme bend or twist of the flexible cervical region of the spine, should have been caused by a fall headlong from a height; or that, with that excessive bending of the spine, the cervical enlargement of the cord should have been bent likewise; or that in that sharp, acute, abrupt flexion of the cord, a blood-vessel should have been ruptured in its interior, and a clot of blood be deposited. In two of the cases mentioned on p. 359, under the head of Sprains of the Neck, the violence of the bend or jolt could not have been so great as in the supposed case of concussion now referred to: yet from the paralytic symptoms immediately attending the injuries in both, it was clear that the cord had been damaged, though slightly and transiently. It may be inferred, therefore, that the accidents were essentially alike, though the lesion and its effects in the one, were much severer than in the others.

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* *Brit. Med. Jour.*, April 24, 1869.

The question of 'concussion of the spinal cord,' and of its phenomena generally, has excited more lively interest in the minds of surgeons, and even among the public generally of late years, than formerly; and that has obviously arisen from the frequent occasions in which it is prominently brought forward, in courts of justice, as the source of numerous formidable evils that result from accidents in railway collisions.* It is important, therefore, to endeavour to understand the precise nature of the injury so designated.

Why the term 'concussion' should have been applied to an injury of the brain, is not difficult to comprehend; but the same cannot be said in reference to the spinal cord.

As the cranium is a hollow sphere, the parietes of which are dense and elastic, it may be readily understood that, if smartly struck at any part, the blow will cause a vibration to run through its walls in every direction. The vibration may travel in some of these lines of direction more readily than in others; but as no *dampers* are interposed anywhere, the shake, or concussion, will be general. Again, the brain completely fills the cranial cavity, fitting closely into all the hollows and sinuosities. But from being of a pulpy or doughy consistence, and withal inelastic, it is incapable of vibrating in harmony with the bony case surrounding it. Hence, when the skull is set vibrating, it is obvious that the vibrations will inflict a succession of blows on the brain. These will vary in force in different cases, but they will follow in rapid sequence; and the multiplication of them, even when comparatively weak, will be injurious to the delicate textures of the brain.

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* The total sum paid, in 1867, as compensation for personal injuries, by the railway companies of the kingdom, was 347,000*l.* One company alone paid 86,000*l.* The number of travellers, that year, was 287,000,000; of killed 19; of injured 638. (*Newspaper Paragraph.*)

In the vertebral column, on the other hand, the structure both of the containing and contained parts is of an entirely different character. The spine is a long, flexible, tubular cylinder, divided into numerous segments. Between each two bones, a damper, in the form of an intervertebral substance, is inserted; and the layers of muscles clothing the spine also intercept vibrations. Again, instead of the spinal cord being in direct apposition to the osseous walls of the vertebral canal, like the brain in relation to the cranium, it occupies the centre of that roomy chamber, and is at a considerable distance from them. Moreover, except at the foramen magnum, the dura mater of the cord (theca) has no attachments to the sides of the canal but what it forms at the intervertebral foramina, through the sheaths of the spinal nerves; and it invests the cord quite loosely in its whole length. Accordingly, even if the spine did vibrate, there would be no connecting medium capable of conducting the vibrations to the cord.

Hence it may be seen that the effect of an injury to the head, as relates to the brain, differs from that of an injury to the spine, as relates to the cord. In the one, the skull undergoes a general shake, and the brain is correspondingly concussed. In the other, the violence falls with principal severity on the most flexible, weak, or exposed part of the spine, according to the direction it takes; and the damage to the cord is local, contrasted with general.

Applying these observations to the effects produced on the nervous system by the injuries chiefly characteristic of serious railway accidents, it does not appear that the term 'concussion of the spine,' so often used in connection with them, has been well chosen. It ought to have been of more comprehensive signification. When a person is involved in a dangerous railway collision—in which the train pursuing its lightning course, has been instantly arrested—the whole body is in a concussion. If any part deserves to be singled out from the rest as especially exposed to have its functions greatly deranged, it will be the brain. The neck of a man represents a stem on which the head is placed; and it is a particularly flexible stem for so great a weight to be put upon it. Accordingly, when the train's career is suddenly stopped, and the carriages bound and rebound, and jump up, and fall again, the head is beyond the patient's power of controlling—it swings in different directions, and is painfully jerked to and fro. He may have escaped actual concussion of the brain; there may not even be found a bruise upon his head; and after a little time—spent, it may be supposed, in the circulation becoming restored to its equilibrium—he may be able to 'shake himself up,' walk about, and resume his journey. Yet no one will be surprised to find that lasting injurious effects have been produced on his brain by the accident. But the head, and the cervical portion of the spine concerned with it, are not the only parts that require additional mention. It cannot be forgotten that the viscera both of the thorax and abdomen partake each more or less the character of 'floating;' that they are suspended at their roots by ligaments, or their equivalents; and that within the folds of the serous membranes which form these connections, not only blood-vessels and absorbents, but nerves, particularly of the sympathetic system, are enclosed. When the body is jolted, jarred, and shaken, in the violent manner described above, it is self-evident that the viscera will be stirred and jolted likewise; that their internal structure will be subject to be bruised or lacerated, giving rise to ecchymosis; and that the nerves on their passage may be stretched, torn, or otherwise injured. Thus all the great constituent parts of the nervous system—brain, spinal cord, and sympathetic system—are included in the common risk of the catastrophe. And the account would be incomplete, if the influences of mental shock—that of fright and of witnessing appalling spectacles—were neglected.*

Progressive paraplegia; chronic degeneration of cord; resulting from injury of the spine.—A chronic disease of the spinal cord, which ends in partial destruction of its substance by degeneration, and during its gradual course is attended by slowly progressive paraplegia, has long been known as an idiopathic affection. Of late years, the same disease has been represented as a sequel of what is called 'concussion of the spine.' It has therefore a claim to be considered in this place.

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* See a series of valuable communications, 'On Cases of Injury from Railway Accidents—their influence upon the Nervous System, and results;' by Dr. Buzzard. *Lancet*, vol. i. 1867, p. 389.

The most eligible way, it appears, of treating this subject will be to illustrate the disease and its phenomena by the narrative of a properly completed case; that is, one in which an account of the post-mortem appearances is included. Cases of that kind are singularly rare. In the newspapers, one reads almost daily of persons being brought into courts of justice—lamentable spectacles, lying in litters, at the threshold of death's gate—plaintiffs claiming pecuniary compensation for personal injuries in railway collisions. But the number of deaths among such persons must be few; otherwise it cannot be understood how the scarcity should be so great of cases in which the results of dissections have been reported. One complete case alone, of that kind, is known to the writer. It is that of a patient who had been under the care of Mr. Gore, of Bath; but whose case was related originally by Dr. J. Lockhart Clarke, to whom the spinal cord had been sent for examination.* The case was afterwards introduced, with additional details, into his work on *Railway Injuries*, by Mr. Erichsen.† Lastly, Mr. Le Gros Clark has published an account of it, illustrated by a woodcut, in his Lectures at the College of Surgeons.‡

In the account of the case which follows, the writer has availed himself of the descriptions given by the different authors just named. But it has to be premised that, as the patient did not come under Mr. Gore's observation till a year had expired from the accident, and then visited him only at intervals, the early history especially is imperfect.

A gentleman, aged forty-eight, met with a shock in a railway collision, but he received no wound or bruise; and only complained of a pain in his back; he walked from the train to a station close at hand. Being a man of active habits, he made every effort to get about in his business; and did so for a short time, though with much distress. Numbness and a want of power in the lower limbs gradually came on, and he became disabled; but the precise time when the paralytic symptoms appeared could not be stated, it being known only that it was less than a year from the time of the occurrence of the accident. He had previously suffered vaguely with pains down the back and in the head, though not of a very acute kind. There was great sensitiveness to external impressions, so that a shock against a table caused distress. He gradually, though very slowly, failed in every respect as to mind and body—not however losing his intellect. He became unable to walk with steadiness and firmness; the semi-paralytic state was somewhat like that of partial intoxication; but there was little, if any, jerking or twitching. Before his death, which was clearly hastened (say three months), by an accidental fall, he could barely walk with the aid of two sticks; and he was for the last month confined to bed. In the latter part of his illness, some weakness of the upper extremities became apparent; so that, if the patient was off his guard, a glass would slip from his fingers. There was not any marked rigidity of the spine, or convulsive movements. Until about eighteen months before his death, there was no paralysis of the sphincter of the bladder; then the urine became pale and alkaline, with muco-purulent deposits. He lived after the accident three and a half years.

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* See 'Report on a Specimen of Disease of the Brain and Spinal Cord, consequent on a Railway Collision;' by Dr. J. Lockhart Clarke. *Trans. Pathol. Soc.*, vol. xvii. p. 20.

† 'The only case on record with which I am acquainted, in which a *post-mortem* examination has been made of a person who had actually died from the remote effects of concussion of the spine from a railway collision, is one that has very recently been related, and the parts exhibited to the Pathological Society by Dr. Lockhart Clarke.' On *Railway Injuries*, p. 113.

‡ *British Medical Journal*, October 3, 1868.

In the brain, there was general, but slight opacity of the arachnoid membrane, and sub-arachnoid effusion. The cortical substance was soft and pallid, particularly at the inferior surfaces of the anterior lobes. Dr. Clarke's report of his examination of the spinal cord is as follows: 'I found,' he says, 'that the membranes at some parts were thickened, and adherent at others to the surface of the white columns. In the cord itself, one of the most striking changes consisted in a diminution of the antero-posterior diameter, which, in many places, was not more than equal to half the transverse. This was particularly the case in the upper portion of the cervical enlargement, where the cord was consequently much flattened from behind forward. On making sections I was surprised to find that of all the *white* columns, the *posterior* were exclusively the seat of disease. These columns were darker, browner, denser, and more opaque than the antero-lateral; and when they were examined, both transversely and longitudinally, in thin preparations under the microscope, this appearance was found to be due to a multitude of compound granular corpuscles and isolated granules, and to an exuberance of wavy fibrous tissue, disposed in a longitudinal direction. It was very evident that many of the nerve-fibres had been replaced by this tissue; and that at certain spots or tracts, which were more transparent than others, especially along the sides of the posterior median fissures, they had wholly disappeared. Corpora amylacea, also, were thickly interspersed through the same columns; particularly near the central line. The extremities of the posterior horns contained an abundance of isolated granules, like those in the columns; and in some sections, the transverse commissure was somewhat damaged by disintegration. The anterior cornua were decidedly smaller than natural, and altered in shape, but no change in structure was observed.' *

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* An interesting point is omitted in the case; it is not stated whether the patient retained sensation through his whole illness, or not. In 1840, a case of idiopathic progressive paraplegia was communicated to the Medico-Chirurgical Society, by Mr. Stanley; in which the most remarkable morbid change found

The first remark which the reading of the above case suggests, is concerning the disproportion that appears between the slight injury sustained by the patient and the magnitude of the results, occupying three and a half years in coming to an end. From progressive paraplegia, and a morbid condition of the spinal cord, identical with what have been described in the case, being known to originate independently of injury of any kind, the question forces itself upon us—was the shock in the railway accident, a cause, or a coincidence? This doubt would not have been expressed if Mr. Gore had been in attendance on the gentleman at first; but, according to the narrative, he did not see him till a year after the accident.

But granting for argument's sake, that a shock, analogous to concussion of the brain, had really been received, the question may be asked: how would that assist in accounting for the peculiar morbid change found in the cord, on dissection? The concussion would be followed by inflammation. But that inflammation would be general: it would extend over the whole surface, and enter into the deep structures of the cord, including every column equally. The organic change, however, is not general, but partial: it is confined to the posterior columns. How, then, is that selection or limitation to be explained?

Another objection presents itself. According to modern views of pathology, the morbid action concerned in producing granular degeneration of the tissues is distinct from inflammation. The process is seen in operation in fatty degeneration of the muscular substance of the heart, in the formation of the arcus senilis, in the production of atheroma in the arteries, &c.; and in none of these instances is the degeneration preceded by inflammation. It may be argued, therefore, that the organic changes in the columns of the spinal cord, consisting of degene-

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on dissection, was disorganisation of the posterior columns of the cord. Shortly afterwards, Dr. Webster communicated a case in which the same morbid condition was discovered. In the first case, a period of three, and in the second, one of two and a quarter years elapsed, before the loss of power in the limbs was complete. But in neither was sensation destroyed. And the principal object of both authors was to direct attention to the latter point; as it was then thought to be at variance with the generally received opinions of physiologists, namely, that sensation was the property of the posterior columns. Six years before the first communication, Sir Charles Bell had shown that sensation did not depend on those, but on the *lateral* columns, of the cord; and that view has been abundantly confirmed by subsequent researches. *Phil. Trans.*, 1834–1835.

ration of the nerve-fibres, depend on some cause, not hitherto ascertained, different from inflammation; and that accordingly their connection with concussion of the cord is merely hypothetical.

On the whole, it may be affirmed, that what is most wanted for the better understanding of those cases commonly known under the title of 'concussion of the spine,' is a greatly enlarged number of post-mortem examinations. Hitherto our experience has been derived almost wholly from litigated cases, deformed by contradictory statements and opinions; and the verdicts of juries have stood in the place of post-mortem reports.*

Fracture of dorsal spine; paraplegia; recovery. Relapse in thirteen years as progressive paraplegia. Death in five years.— The following case, in its principal circumstances, is singular; it is introduced here as bearing on the subject of 'progressive paraplegia,' connected with injury.

H. P., aged forty-four, a shoemaker, was admitted into the Middlesex Hospital, under the writer's care, in May 1849, with paraplegia, and bed-sores. Twenty years before he had fallen from a second-floor window in Edinburgh, and was carried insensible to the Infirmary. On the following day consciousness returned; and he then found that his back had been broken near the middle, and that he had lost the power of motion and sensation in both lower extremities. Blood in clots was mixed with the urine; and the bladder had to be washed out with warm water. He began in two months to void his urine without assistance, and to regain some power over his limbs. Issues were applied near the seat of injury. In four months, having recovered the power of walking, he was discharged from the Infirmary; and shortly afterwards returned to his work. The only remains of the paralysis at that time was defective sensation in a small part of the right leg. During the seven years following, he was uninterruptedly well, and led an active life—occasionally travelling abroad on business. He then had a fever, which he ascribed to catching cold on a diligence. Twelve months afterwards, he had pain at the seat of injury in the back; and the surgeon who had attended him formerly advised him to renew the issue there. Again, for five years, he remained in perfectly good health. It being now thirteen years since he met with the accident, a serious change in his condition commenced. His legs then began to be weak under him; and he dragged them heavily as he walked. The feebleness of the limbs gradually and slowly increased; so that having been able, at first, to get about with one, he was soon obliged to use two sticks, and afterwards crutches. In five years, he was so incapacitated that he took to his bed, and remained there for two years before his admission. When bed-ridden, both motor power and sensation were quite lost in the lower extremities; he was unable to retain either the fæces or urine; and extensive sores formed on the hips. During the whole progress of the paralysis, his lower limbs were frequently disturbed with convulsive startings, brought on without perceptible cause; and for the last six months, the legs were closely bent on the thighs, and the knees drawn up to the abdomen.

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* There has been recently communicated to the Medico-Chirurgical Society, a case of concussion-lesion. A man fell from the top of a hayrick, and had partial paraplegia, loss of motor power, without that of sensation. He lived six months. On his death, the medulla oblongata and spinal cord were examined under the microscope. Extensive granular degeneration was chiefly found; the structural changes by which are represented in twenty-one figures. It is remarkable that, notwithstanding the great amount of disorganisation, the patient gradually recovered the power over some of the limbs that had been paralysed, and he retained sensation unimpaired to the last. The case was, therefore, not one of 'progressive paraplegia,' to be referred to in the text. 'On a Case of Concussion-Lesion, with extensive Secondary Degeneration of Spinal Cord, followed by general Muscular Atrophy;' by H. Charlton Bastian, M.A., M.D., *Lond. Med.-Chir. Trans.*, vol. l. p. 499.

His admission into the hospital was twenty years after the fracture of the spine, and seven after the relapse, or commencement of the progressive paraplegia. A slight incurvation of the column forward, and faint indication of an angle about the fifth or sixth dorsal vertebra were observed; but, owing perhaps to an œdematous condition of the skin generally, no unevenness in the spinous, or other processes could be detected. He did not complain of pain, and bore strong pressure and percussion along the column without suffering. Paralysis was complete in all the parts below the level of the umbilicus, both as to motor power and sensation. As stated before, his legs were rigidly bent, and the knees drawn close to the body, and he had no voluntary power whatever in them; but they were subject to slight reflex actions. Sensation was absolutely lost; but a source of deception was observed; that is, when blindfolded, and one of his legs was pricked, he was able to distinguish which was touched; it was found, however, that this was owing to the leg experimented on starting each time, and communicating a jar to the corresponding side of his body. There was incessant dribbling of the urine, and the fæces passed involuntarily. An extensive sore was situated over the sacrum, a portion of which was denuded and black; and there were sores likewise over the ischia and trochanters; in all, the surfaces were foul and sloughy, and of great depth; but quite painless, as shown by the patient being unconscious when strong caustics were applied.

By giving generous diet, with abundant stimulants, assisted by quinine and opium, the patient, who had been in a reduced condition, rapidly gained considerable strength. He was put upon a water-bed at first, and latterly on a spring-bed. The dressing to the bed-sores was chiefly balsam of Peru. It was an interesting fact that the deeply excavated sores soon lost their foul surfaces, threw out laudable pus, became filled with healthy granulations, and cicatrised on a level with the surrounding skin, as quickly as was ever witnessed in patients of the soundest constitution. The only part where the process of skinning failed was at the centre of the sacrum, where the bone was bare. The bowels were habitually costive; and when that state lasted for some time, he felt oppressed in his breathing. He lived for eight months. As his end approached, he was subject to profuse perspirations; and a singular circumstance was observed concerning them—namely, that the paralysed parts were not included: the hair of his head would be wet, as if it had been in the sea; large drops of sweat would be upon his face; and his shirt would be drenched, as if just out of the wash-tub; yet not a sign of moisture would be visible on his lower extremities, or anywhere below the line of the umbilicus. His death was marked only by symptoms of extreme exhaustion.

Post-mortem appearances.—Fracture was discovered to have taken place in the fifth dorsal vertebra; but the union of the fragments was so compact, or the surfaces so much fused together, that the lines denoting the original breach were indistinct, and the fact was made out chiefly by observing the relative displacements. The direction of the fracture, then, was through the body, between its upper and middle thirds; and backwardly, through the arch, and upper articulating processes; the superior fragment had been slightly thrown forward and downward upon the inferior; so that a moderate bend, and an inclination to the left, were the consequences. The fourth vertebra had become united, by anchylosis, to the upper surface of the superior fragment; and the junction was so close, that the bodies were fused, and the intervertebral foramina obliterated. The sixth vertebra was not united directly to the inferior fragment; but bony outgrowths had been thrown out in front of the respective bodies, like buttresses, as if to give additional strength at the angle of fracture; and two adjacent ribs were united, on the right side, near their articulations, close to the seat of fracture. The vertebral canal partook of the incurvation caused by the displacement of the fragments; but its capacity was normal, and the surfaces even; a thin, dense osseous plate, took the place of the posterior longitudinal ligament, and lined the backs of the bodies of the vertebræ, including the intervals occupied by the intervertebral substances, so as to make a continuous smooth surface.

The spinal cord and sheath together were visibly collapsed, at the seat of fracture; both as compared with the magnitude of the canal, and the size of the cord above and below. For an inch, some soft, apparently fibrous matter, surrounded the sheath on the outside, without adhering to the walls of the canal. A portion of the cord, about two and a half inches in length, was so much disintegrated that its form and colour were lost; and a friable, granular material, easily broken down, and amorphous in appearance, took the place of the healthy structure. The same morbid matter was the medium of adhesion between the remnants of the cord and the meninges. The continuity of the upper with the lower portions of the cord was preserved, as it appeared, entirely by pia mater and connective tissue; there being no vestige of nerve-structure visible to the naked eye. All traces of roots of nerves within the theca were obliterated.*

FRACTURES AND DISLOCATIONS OF THE SPINE.

When violence greater than the spine is constructed to withstand is directed upon it, and it yields to the force, the injury almost invariably consists in mixed fracture and dislocation. This union of the two is readily understood when we take into view the irregular forms of the vertebræ, and the over-lapping of their various processes. In the dorsal region the bones are so closely locked, and the processes, especially the spinous, so long and overhanging, that simple dislocation appears impossible; but in the cervical and lumbar regions, where motion is free, and the articular surfaces are either more horizontal than vertical, or the processes stand out apart, a considerable amount of dislocation may take place, accompanied with but little fracture. For example, a case has been related by Mr. Holmes, of a man struck on the loins by a heavy log of timber; the last dorsal vertebra had been dislocated from the first lumbar, with laceration of the intervertebral substance; but the fracture of the processes was so inconsiderable, that the fact of their having been crumbled, rather than broken, might easily have escaped notice.*

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* The preparations connected with this case are contained in the Museum of the Middlesex Hospital.

And, practically, the question of the proportionate amount of fracture compared with dislocation, is in most cases of little moment. It would be founding on a false analogy to suppose that, because it is important in a case of accident to the hip, shoulder, elbow, &c., to recognise distinctly the nature of the injury, whether it be fracture or dislocation, the same thing held with regard to the spine. What renders injuries of the back of gravest interest to the surgeon, is the question of the condition of the Spinal Cord; and that organ is equally liable to be crushed, and have its functions destroyed, by fracture, or by dislocation. As to the treatment, if reduction of the displaced bones be required, the method of effecting it will be the same in both kinds of injuries; and as to prognosis, the prospect of recovery is not more or less encouraging in the one than in the other.

The forces which cause fracture of the vertebræ (comprehending in that term, for the convenience of expression, partial dislocation) are necessarily violent; they also fall upon the flexible column in many different directions; and they produce thereby a great diversity in the injuries. It will simplify the subject, if we distinguish fractures into those which come from *indirect*, and those which come from *direct* violence. Injuries affecting the two highest vertebræ, as they have certain special characters, will be considered afterwards by themselves.

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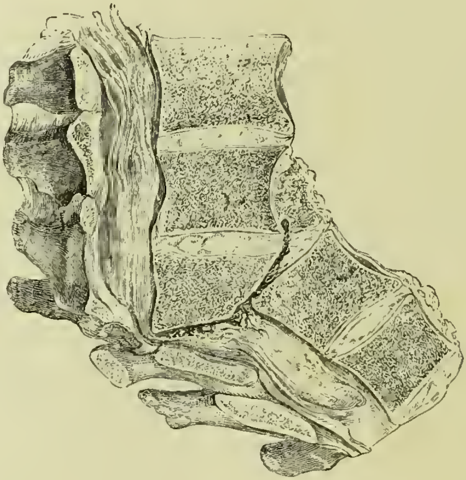
* *Pathol. Soc. Trans.* vol. x.

On fractures of the spine from indirect force.—

A miller's carman was standing in his waggon, receiving heavy sacks of corn let down by ropes from the high story of a granary; the fastening of one of the sacks slipped; it descended, and alighted on his neck and shoulders: the spine was fractured at the fifth dorsal vertebra. A young gentleman was sitting on the branch of an apple-tree, when it broke, and he came to the ground on his nates, which left their impression on the soil: the spine was broken at the eighth dorsal vertebra. A man falling headlong from a height, came to the earth upon the vertex: bruises of the scalp were visible at that part, and it was found that he had fracture of the lowest cervical vertebra.

All these cases were examples of the spine being broken in a transverse direction, consequent on the column having been bent to an excessive degree; and that by forces which bore upon the column, not in the line of the fracture, but along the longitudinal axis. In examining the body of a person who has died shortly after such an accident, the following appearances will be observed: blood will be extravasated extensively in the neighbourhood of the fracture; at the lumbar region,

Fig. 60.*



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* Example of fracture of the spine from indirect violence. The patient, a young man, had fracture through the eleventh dorsal vertebra, from a heavy weight falling on his shoulders, and doubling him up. He survived, with paralysis and anæsthesia of the lower extremities, for eight days. The two ends of the spinal cord, where it and the theca were torn, were one and a half inch apart. Preparation in Museum of Middlesex Hospital.

one or two of the supra- and interspinous ligaments will be ruptured, and a gap made between the corresponding spinous processes ; at the dorsal, a chipping-off of the slender ends of these processes will more probably be met with ; there will be partial laceration of the muscles and tendons in the vertebral grooves, at the seat of fracture. Proceeding more deeply, the ligamenta subflava connecting the arches of the two vertebræ most involved in the injury will be found torn off from the margins of the laminæ. The injury to the articulating processes will differ in the several regions : in the dorsal the ligaments will be torn, and the processes themselves be almost certainly broken ; in the cervical, the ligaments will be ruptured, but the processes may either escape fracture, or have their edges merely chipped ; they will probably have been dislocated, but owing to the surfaces of these processes being comparatively broad and nearly on the same horizontal level with the bodies of the vertebræ, they frequently fall into their places again after the separation ; thus constituting it a case of *diastasis*, rather than of dislocation. In the lumbar region, the articulating processes will be wrenched asunder, like teeth drawn from their sockets ; but when the vertebræ settle down the processes will not return to their original situations—one or both will hitch upon some point of the subjacent vertebra, on which they can rest ; the bones will thus be locked and permanently displaced, there will be a distinct bend, acompanied with a twist of the spine, and the transverse processes of one side will project visibly against the skin. Consequent on the separation of the articulating processes and the simultaneous rupture of the ligamenta subflava, the interior of the vertebral canal will be opened and the sheath of the spinal cord exposed, probably obscured by extravasated blood. Omitting, at present, to speak of the medulla spinalis itself, attention may next be drawn to the state of the front of the column, viz., the bodies of the vertebræ and intervertebral substances. In treating of Sprains it was stated that when the spine is bent forwards and downwards, the force directed on it in front is one of compression, as distinguished from laceration. Accordingly, in cases of fracture caused by excessive bending, the injurious effects on the bodies of the vertebræ will be due to crushing in contradistinction to tearing. It might perhaps have been thought that when the ligaments and other structures at the back of the spine had been rent, and the superincumbent weight was thus thrown exclusively upon the bodies and fibro-cartilages, the latter would have been detached from the surfaces of the bones, rather than that the bodies should be broken. But such laceration of the intervertebral substances is rare. The chief injury inflicted consists in a breaking down of the body of the particular vertebra which is situated at the angle of flexion, and the fracture is a combination of 'comminuted' and 'impacted.' With the fracture of the body, the longitudinal ligaments in front and behind are commonly torn. The upper fragment may glide a short way downwards and forwards upon the lower, and in that manner overhang it; but owing to the locking of the processes behind, that motion is arrested and the displacement is never considerable. In others, when a triangular portion of the body has become loose, it has been driven back, owing to the compression being greatest in front, with the force of a wedge into the vertebral canal, so as to encroach on the spinal cord.

On fractures of the spine from direct force: dislocation.—Owing to the spine being protected on its fore part, it is not liable to be injured by direct force except from behind. Again, when direct violence sufficiently great to produce fracture is applied, it causes the column to bend backwards, before breaking; or in an opposite direction to the incurvation preceding fracture by indirect violence. Hence, according to the mechanical law before referred to, the structures in front will be subject to laceration—those behind to compression: in other words, before the spine breaks, the bodies of the vertebræ, intervertebral cartilages, and longitudinal ligaments will resist the action of being torn; while the pedicles, laminæ, and processes of the posterior segment will resist the force of compression.

As the vertebræ in the dorsal region are curved anteriorly, and so firmly locked together as to be nearly inflexible, it is not to be expected that they will yield readily to a force bending them in the contrary direction. But the case will be different in the cervical and lumbar regions. In each of these the natural curve is backwards, and these are also highly flexible. We may conclude, therefore, that when either part is subjected to direct violence, and the incurvation is increased beyond the normal point, the bodies of the vertebræ will be divorced from each other, and the intervertebral cartilages stripped from their surfaces; but that the posterior arches, together with the articular, transverse, and spinous processes, will be compressed, ground, and crushed. From this it will be seen how much more likely dislocation is to enter into the composition of a direct than an indirect fracture. If one of the intervertebral substances have been torn, and the surfaces of the bodies of the corresponding vertebræ separated, there will remain only the joints of the articulating processes to hold the bones together; and when these have been broken, nothing will be left to prevent displacement of the fragments. The case related by Mr. Holmes, already adverted to, of dislocation at the dorsi-lumbar region, illustrates this view. The patient had been struck on the loins by a heavy piece of timber, and his lower extremities and bladder were immediately paralysed: the lowest dorsal vertebræ were observed to be half an inch in advance of the level of the lumbar vertebræ: by extension, the bones were restored, with an audible click, to their proper places; after death the intervertebral substance between the last dorsal and the first lumbar vertebræ was found ruptured, and the anterior common ligament stripped off the body of the latter bone; the articular processes on both sides had been separated, and there was partial fracture of the transverse processes.

A remarkable case of fracture in the lumbar region, combined with dislocation of an extraordinary amount, caused by direct violence, has been recorded lately by Mr. Le Gros Clark; and the description of the injured parts is illustrated by a woodcut. The patient had received a blow on the back, by the fall of a heavy weight, and paralysis of the lower extremities was the consequence. The intervertebral substance between the fourth and fifth lumbar vertebræ, and other connecting ligaments of the bodies, had been completely torn; the arch of the fourth vertebra had also been broken at its pedicles, on each side; and the articular, transverse, and spinous processes, in relation with the fifth vertebra, were so crushed or comminuted, that an effectual loosening between them had taken place. The fifth vertebra had preserved its place upon the sacrum, defended from injury by the projecting posterior spinous processes of the ossa ilii on its flanks. But the body of the fourth vertebra—with its superstructure, the spine—had been forced downwards and forwards in the direction of the pelvis, to such an extent by the weight, that it was found to have taken its place in front of the body of the fifth vertebra, in the manner of front and rear rank; the upper and under surfaces of the bodies of both vertebræ being respectively on the same horizontal level.*

Of injuries to the spinal cord consequent on fracture.—When the vertebral column is broken across at any point between the occiput and the second lumbar vertebra, where the medulla spinalis terminates, that important organ partakes of the injury; it is deprived of its functions, and all the body below the fracture at once loses, more or less completely, both motor power and sensation: in other words, the patient is affected with paraplegia.

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* Lectures on the Principles of Surgical Diagnosis, delivered at the Royal College of Surgeons; by Mr. F. Le Gros Clark. *Brit. Med. Journ.* October 3, 1868.

From this statement it will be perceived that the higher in the spine the fracture occurs, the graver will be the consequences. But before attending to the differences in the effects referrible to the extent of the body paralysed, let us examine the lesions produced in the spinal cord itself and its membranes, from the injuries.

Owing to the small size of the medulla, it is seldom destroyed partially; the columns which give motion and those which give sensation are almost always deprived of their functions simultaneously. When exceptions occur, and one property alone is destroyed, it is motor power that in the majority of cases is lost.

The lesion of the cord varies in different cases. 1. When the displacement of the vertebræ has been extreme, the theca has been found torn through, and the cord itself ruptured, with the ends separated to a distance of two inches from each other. 2. In many cases the medulla is intruded upon by the sharp edge of an angular fragment of vertebra; the theca and other membranes are penetrated, and the organ itself cut and torn across: in the majority of such cases, the fragment which projects into the canal is a part of the body, and is therefore situated in front. 3. In the cervical region, when the vertebræ have been both torn from each other, and extensively bent, the cord may be found not only crushed, but burst; from the violence of the squeeze, the pia mater will have given way, and the medullary substance, converted into a thin pap, will have escaped and be spread on the surface of the organ above and below the rupture. 4. The structure of the cord is not unfrequently disintegrated through its whole thickness; and yet from the pia mater being entire, the organ may retain its natural figure, or there may be a slight swelling alone visible, without discoloration; but when the finger is carried along the surface, with the view of judging of its consistence, and comes to the part corresponding to the seat of fracture, the cord will be felt soft, as if broken; and on a section being made, the medullary and cineritious matter will be found diffluent, commingled, and stained in the centre with blood. 5. The terminal portion of the cord where it tapers to a point, opposite the two last dorsal and two first lumbar vertebræ, is surrounded by a congeries of roots of the nerves which form the cauda equina; these roots enveloping it serve to protect it to a considerable degree from injuries incident to that region of the column. The writer has seen a small superficial indent in the cord, covered by the roots at this part, produced by fracture. Lastly, below the second lumbar vertebra, the spinal canal contains only the sheath, and the cauda equina within it. It is obvious that the effects of injuries of the column in this locality will differ greatly from those in other situations, on account of the absence of the spinal cord. Both from the firm consistence of the roots composing the cauda equina, and the toughness and looseness of the sheath, the parts will yield, and adapt themselves to extensive changes in the canal, produced by displacement from fracture, without losing their functions.

In lesions of the spinal cord, the hæmorrhage is generally slight; and it differs in all cases, both in its mode of occurrence and effects, from what is met with in injuries of the brain. The arteries and veins which permeate the medulla are remarkable for their minute size: hence, when a portion is cut or bruised, the bleeding soon stops, and extravasation on the surface, or ecchymosis in the substance of the organ to a considerable amount, is rare. If the latter take place, it will be greatest in the central cineritious matter. The hæmorrhage in fracture of the spine proceeds chiefly from laceration of the large venous plexuses which line the interior of the vertebral canal. The blood collects on the outside of the cord and its membranes; and as the theca adheres rather firmly in front, but on the lateral and posterior parts somewhat loosely to the canal, the accumulation of blood is commonly greatest behind and at the sides.

Consequences of destruction of the spinal cord from fracture stated generally.—When a man has met with an injury of such severity as to give rise to fracture of the spine, there is a general shock to his nervous system, and he is found, at first, in a state of profound collapse. When restored, he complains of pain at the seat of the injury, especially if any attempt be made to move him. The tumefaction at the painful part, together with irregular projections and depressions in the processes of the vertebræ, divulge the nature of the accident. It is soon perceived that his whole body below the level of the fracture is completely paralysed. If a line, corresponding to the distribution of the nerves which come off immediately above that part, be drawn around his chest or abdomen, he will be incapable of feeling, when pricked or pinched, in any part of the skin from that line to the soles of the feet; he will be unable to move any joint of his limbs; there will not even be reflex actions of the muscles. The urinary bladder will have lost the power of expelling its contents; and as the kidneys go on secreting the ordinary quantity, it will ere long be over-distended. As the patient is not prompted by the natural call to pass his water, the bladder will at length be elevated as high as the umbilicus, feeling like a hard globular body, and giving out a dull sound on percussion. The fæces will also be retained; at first, with obstinate costiveness; afterwards, the stools will pass involuntarily; but the patient will not be aware of their escape, or of their presence when they lodge on the bed-clothes. There will be priapism, in greater or less degree.

Fracture in the dorsi-lumbar and lower lumbar region.—It will be convenient, in treating of fracture as it occurs in the several regions of the spine, to commence with those about the base; the effects being less complicated there than higher in the column.

So generally does paralysis of the lower extremities result from fracture of the spine, that the two events are apt to be looked on as inseparable. Yet, when the column is broken below the second lumbar vertebra, there may be an absence of paralysis. The patient will be unable to keep the body erect; and he will be incapacitated from walking; or he will carry himself lamely in a bent posture. But lay him on his back, and he will throw his limbs freely about, and sensation will be perfect. As soon as there has been time for union of the fragments, he will be well, except for the deformity that may remain. The reason of this difference in the effect of fracture of the spine when it occurs in the part specified, compared with other places, is that the injury is below the level of the spinal cord, which, it has been already stated, terminates at the second lumbar vertebra. From that bone downwards, the vertebral canal is occupied only by the cauda equina, protected by the membranous sheath; these are suspended loosely in their place, so that even if the displacement of the fragments, in cases of fracture combined with dislocation, be great, the long, flexible, cord-like roots composing the cauda can slip aside, elude positive injury, and retain their functions.* It may be expected, however, that exceptions will be met with. If the separation of the broken fragments has been extensive, the fibres of the cauda equina will be torn from their connections with the cord; and it is probable that the injury to the latter from that cause will give rise to paraplegia.*

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* Four cases of fracture in the lower lumbar region, in which there was total absence of paralysis, have come under the writer's observation. In the

If the fracture has taken place at a point higher up in the spine—as between the second upper lumbar, and second lower dorsal vertebræ—in which situation the cord is surrounded by the closely-set roots of the cauda equina, it may be expected that the effects will be moderated by the protection which the roots give to the cord. When the fracture has been caused by excessive violence, and the column has been abruptly bent, and the fragments much displaced, it is probable that the injury will reach the cord, and the paraplegia be of the usual kind. But it appears that, in numerous instances, the roots ward off the danger, and the lesion of the cord is consequently slight. In proof of this, it will be found, by examining the records of cases in which fractures have occurred in this locality, that in a large proportion of them the paraplegia which has ensued is only partial—motor power, in the greater number of examples, being lost, while sensation remains. Again, in further confirmation, it will be perceived that the number of cases in which

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first, the displacement was so great, that the spinous and transverse processes projected visibly; the fragments were interlocked, so that the spine could not be straightened, and the patient's body was permanently much bent: yet motion and sensation in the lower extremities were retained from the first. See *London Medical Gazette*, vol. xviii. p. 936, 1836. For the other three cases, see *Transactions of the Pathological Society of London*, vol. iii. p. 420. Among the latter, was that of a boy who was eight years old when his case was published. Fourteen years afterwards (1865), he called, to show the condition of his spine. There was relatively greater prominence of the displaced vertebræ than at first; but the column was on the whole nearly straight, and his muscles were powerfully developed. Casts of the back, at the two different periods, are preserved in the Museum of the Middlesex Hospital.

'In one case I found the trunks composing the cauda equina lifted a third of an inch on a bridge of bone, formed by the displacement of a fractured lumbar vertebra; but they were in no degree compressed, and except a little ecchymosis in their pia mater, showed scarcely any trace of injury.' Mr. Hutchinson, in *London Hospital Reports*, vol. iii. p. 360.

* In the case of fracture with dislocation of the fourth lumbar vertebra, quoted at p. 385, in which the fragments were displaced in an extraordinary manner, there was complete paraplegia at first. But in five weeks the patient recovered sensation perfectly, and motion partially. He died in the seventh week, exhausted by sloughing bed-sores.

patients have recovered the power over their limbs and sensation, when these have been lost from fracture at this part, is much greater than in any other.*

Fracture in the dorsal region, between the tenth and fourth vertebræ. Owing to the small size of the cord at the part here denoted, it is liable to be crushed through its whole thickness, when the spine is broken anywhere in its course. Complete paraplegia may therefore be anticipated: the lower extremities will be deprived of motion and sensation; the bladder and rectum will be paralysed, and the patient be exposed to have extensive sloughs on his back. Respiration will be imperfect, but not to such a degree as of itself to imperil life. From the diaphragm and upper third of the thorax continuing to perform their functions, inspiration will be accomplished with considerable force. But, owing to the paralysis of the abdominal muscles, the act of expiration will be feeble; yet it will be effected—first, through the elasticity of the walls of the chest, which will descend and collapse with a certain impulse, at the end of each inspiration; and, secondly, through the resilience of the abdominal viscera. If the patient should have had fracture of one or more ribs in connection with that of the spine, or, before the accident, had been subject to chronic bronchitis, the dyspnœa will be dangerously aggravated. If the patient's life be prolonged till union of the fracture has been effected, the probability of his surviving, although with paralysis remaining, is much increased. And some circumstances favour the procuring of union, in cases of fracture about midway in the dorsal region. First, owing to the rigidity of the column at this part, the displacement of the fragments is not commonly so great as elsewhere. Secondly, from the ribs acting on each side like splints, and the extensive overlapping of the processes of the vertebræ, the broken surfaces are kept in apposition and at rest. Should union be obtained, an important advantage will be gained, especially in regard to the healing of the bed-sores. The large sloughing sores, with profuse discharge, which form over the sacrum and adjoining prominent bones, with formidable rapidity, in cases of fracture of the spine, are known to be frequent causes of their fatal termination. And that which principally gives rise to these sores and prevents their healing, is the constant pressure to which they are subject, from the inability of the patient to change his position, and the irritation produced by his lying unconsciously for long periods on parts of the bed wet and soiled from the urine and fæces passed involuntarily. The chief difficulty met with in endeavouring to avert these evils proceeds from the breach of continuity in the spine, considered as the beam that ties the upper to the lower divisions of the body. It is obvious that, owing to the loosening of the connection between the superior and inferior portions of the column, at the seat of fracture, a movement of the pelvis and lower extremities will not be accompanied with a corresponding movement of the trunk above, but that the lower fragment of the spine will rotate on its axis, while the higher will remain stationary. Whatever care, therefore, be taken by intelligent nurses, in turning the patient successively on different sides, to protect the sores from pressure—however attentive they may be, in moving one division of the body, to make the other move along with it—a great deal of friction between the opposing broken surfaces will be produced, most prejudicial to union, and the source of irritation to the system. But if the patient should live sufficiently long for the ends of the fragments to be knit together, even although it be only by fibrous connections at first, and more especially by ossific matter, the obstacles referred to will be removed. It will be practicable and safe to keep him lying on each side alternately, and the sores will immediately put on a healing aspect.

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* A series of five cases of recovery from paraplegia, caused by fracture of the spine in the dorsi-lumbar and lower lumbar regions, all occurring within a short period of each other, has been recently published in the third volume of the *London Hospital Reports.* The titles of the cases are subjoined:—

'Fracture of the Spine in the lower lumbar region, with displacement—Paraplegia, with Paralysis of the Sphincters—Gradual improvement—Recovery in four months,' p. 326.

'Fracture of the first Lumbar Vertebra with slight displacement—Incomplete Paraplegia at first—becoming more complete two or three days afterwards—Nearly complete Paraplegia for a fortnight—Gradual improvement—Perfect recovery,' p. 327.

'Fracture of Spine, with displacement, in lumbar region—Paralysis of lower extremities, bladder and bowels—Recovery in three months—Power of walking regained; but certain parts of the integuments of feet and nates still quite without sensation,' p. 332.

'Fracture of Vertebræ, with displacement in upper lumbar region—Paralysis of motion and sensation in the lower extremities—Retention of urine and fæces—No priapism—Recovery in six months,' p. 335.

'Fracture, with displacement, in the mid-lumbar region—Symptoms of spinal injury not recognised at first—Incomplete Paralysis of lower extremities —Recovery,' p. 346.

Fracture in the cervico-dorsal region.—This part of the column, it has been already stated, being the point of junction between a flexible and inflexible portion of the spine, is peculiarly liable to fracture. It is understood to comprise within its limits the vertebræ from the second lowest cervical to the second highest dorsal, inclusive. When fracture occurs here, the forms of the bones permit them to return easily to their normal relations, so that extensive permanent displacement is not commonly to be looked for—a too great loosening and mobility of the fragments is the chief characteristic. The kind of injury sustained by the cord is that of being crushed and broken down in its substance, rather than being compressed, or encroached upon in its sound condition. When the cord is so injured, all the body below the seat of fracture is paralysed. On the front of the chest there will be sensation in the integument as low as the nipples; which is to be accounted for by branches of the superficial cervical plexus descending to that level; and if the injury to the cord has been above the origin of the first dorsal nerve, which joins the axillary plexus, some impairment in the motion and sensation of the upper extremities will be discovered. But the principal danger overhanging the patient is connected with his respiration. The whole series of intercostal muscles, with those of the abdomen, are cut off from their share in the action. As the principal trunk, however, of the phrenic nerve, which controls the diaphragm, comes off from the spinal cord above the seat of fracture—emerging at the interval between the third and fourth cervical vertebræ—that muscle continues to perform its important office of enlarging the area of the chest in inspiration; and as, at each relaxation of the diaphragm, the abdominal viscera, which had been thrust downward in its contraction, recoil by their elasticity toward the chest, the lungs are emptied of their air in expiration. But it is obvious that if the latter act were of the simple kind implied by the foregoing description, its operation would be extremely feeble; and that a patient breathing in that manner would not be able to expel the air with force, as in coughing or sneezing. It is to be remembered, therefore, that certain muscles lie on the outside of the chest, auxiliaries of the diaphragm and intercostal muscles. The strongest and most important of these is the serratus magnus anticus, which, upon the scapulæ being raised and fixed, acts as a powerful muscle of inspiration.

The external thoracic nerve (external respiratory, Bell), which supplies the serratus muscle, is a kind of ally, in point of origin, of the phrenic; for it arises from the cervical portion of the cord, only a single vertebra below it, and descending behind the axillary plexus, is distributed on the outside, as the phrenic is in the inside, of the thorax. The effect of the action of the serratus is to elevate and expand the chest, by operating on the eight superior ribs to which it is attached. Accordingly, when it relaxes, the elasticity of the chest causes the ribs to fall with an impulse, and to compress the lungs, thereby effecting an act of expiration. Thus both actions of respiration gain increased strength from the assistance furnished by the serratus muscle. The breathing can, therefore, in certain cases, be carried on for several days without considerable difficulty. But it becomes gradually more and more embarrassed. Owing to the paralysis of the abdominal muscles, the hollow viscera are deprived of the compression naturally exercised upon them; hence gases are apt to be enveloped within them, and the tympanitis thus produced disturbs the respiration. Again, from the difficulty of expelling the air from the lungs, the mucus accumulates more or less abundantly in the bronchial tubes, and cannot be duly expectorated: the consequence is that the blood is imperfectly oxygenated. In the majority of instances, patients do not survive beyond five or eight days; but in a few the term extends to ten or fifteen.

When fracture is situated higher up in the neck, but is still below the point at which the phrenic nerve comes out from the cord, say at the fifth, or even fourth, cervical vertebra, and the upper extremities are included in the paraplegia, death may commonly be expected within a few hours, or at most a day or two. Nevertheless, extraordinary examples are occasionally met with of patients living for a long time after the fracture.

A notable case of that kind has been recorded by Mr. Hilton. The patient, at the age of twenty-one, fell from a tree, a height of forty feet, and had fracture of the spine in the cervical region. The arms as well as the legs were paralysed; so were the rectum and bladder. He lived for fourteen years in that paralysed condition, and at last came to his death by being upset on a hard road, while being drawn on a low cart by a boy.*

The writer is indebted to Mr. Page, of Carlisle, who attended the patient, for the following notes of a still more remarkable case:—

'A gentleman, twenty-six years of age, the heir to extensive landed property in the south of Scotland, while in the act of running on the edge of a terrace adjoining his father's mansion, accidentally fell upon a hard road beneath, a height of ten or twelve feet, and injured his neck. From that moment every part of the body, with the exception of the head, was completely paralysed, the power of rotating the head being all that remained to him. In that state, without the slightest variety as to the extent of the paralysis, he continued up to the time of his death; which took place nearly fifteen months after the accident. At the post-mortem examination, it was found that the spinal column in the region of the neck had received a twist, which had caused some lateral displacement of the spines of the vertebræ; and this had given rise to the supposition that several of the bones had been implicated in the fracture. Such, however, was not the case, the fracture being limited to the fifth cervical vertebra; the body of which had been fractured horizontally, and a wedge-shaped portion broken off, which projected about a sixth of an inch into the canal. The whole bone, with the exception of that portion, was driven slightly forwards; consequently the size of the canal at this part was lessened, but not to such an extent as to compress the cord. Opposite the projecting wedge of bone, the cord was so nearly divided, that a portion only, of less size than a crow-quill, remained entire for a space of about three-eighths of an inch. Above and below this, the cord was reduced to a softened pulp; but beyond, it was firm and healthy. There could be no doubt but that the severance of the cord and the damage in the immediate neighbourhood of that point were inflicted at the moment of the accident.'[*]

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* See *Lectures on Rest, &c.*, originally delivered before the Royal College of Surgeons.

Fracture at the summit of the spine.—If fracture of the spine, attended with crushing of the cord, should occur above the level of the fourth cervical vertebra—that is, above the origin of the phrenic nerve—it may be considered certain that instant death will ensue.[†] The vertebræ most frequently the subjects of fracture

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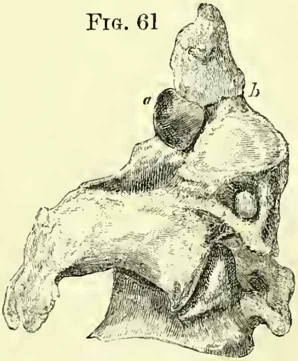
[*] Dr. Smith, of Moffat, with Dr. James Duncan and Mr. Syme, of Edinburgh, also attended the patient. Dr. Duncan, who conducted the post-mortem examination with Mr. Page, in a communication to the author, states that the fourth cervical vertebra was the one fractured.

[†] Mr. Curling has related a case in which the first, second, and third cervical vertebræ were fractured, and the patient lived for twenty-eight hours after the accident. The injury was caused by a heavy sack falling on the patient's head. On dissection, the cord was found, opposite to the third vertebra, in a state of pulpy softening, with slight extravasation into its substance. The explanation which Mr. Curling has given how the patient survived so long, appears correct. It is to the effect, that the force producing the fracture had probably been directed chiefly on the posterior segments of the vertebræ; that, at first, the cord had been injured only partially, but that subsequently its whole substance had been involved, and that instantaneous death took place when the destruction was complete.

Mr. Curling adds another case, in which the third cervical vertebra had been completely dislocated, without fracture, from the fourth, and the patient lived for two days and a half. That the phrenic nerves preserved their functions during that time may be accounted for from the roots of the fourth cervical nerve coming off from the cord a little higher than the level of the articulations between the third and fourth cervical vertebræ; and they may, therefore, have or dislocation in this situation are the two uppermost, the atlas and axis. If a man be precipitated from a height and light upon his head, the impetus of his weight will be conveyed along the spine, and be concentrated at the junction of the column with the base of the skull. Again, the portion of the skull between the point where the head came to the ground and the joint will act with lever power to increase the effect.* A violent shock and strain will thus be directed on the atlas and axis. The effects produced vary somewhat. Perhaps the most common is fracture of the processus dentatus of the axis, at its root, with laceration of the ligamentous connections between the two bones, and dislocation of the atlas forwards. In other cases, the tooth-like process slips from the grasp of the transverse and restraining ligaments, and, freeing the atlas, allows it to slide forwards with the head. Again, the transverse ligament may be ruptured, so as to liberate the processus dentatus, and lead to dislocation. Finally, there may be transverse fracture of the slender arch of the atlas behind the articular processes. In all these injuries but the last, the atlas will have ceased to be restrained by its connection with the odontoid process from sliding horizontally forward on the axis; the weight of the head will, therefore, carry it in that direction, and the cord will be compressed, by a to-and-fro action, between the ring of the axis which is stationary and that of the atlas which advances. Its substance will be broken up; and the effect will be instantaneous death, as when an animal is 'pithed.'†

FIG. 61



a, pistol-bullet; *b*, fissure at base of odontoid process of axis.

In the Museum of the Middlesex Hospital there is preserved the axis taken from the body of a gentleman, who had been shot in the neck, close to the occiput, while asleep, lying on his side. The pistol-bullet had entered at the mesial line, between the arches of the atlas and axis, had passed horizontally forward,

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preserved their connection with the cord. *London Hospital Reports,* vol. i. p. 138. Also vol. iii. p. 358.

* See *antea*, p. 358.

† The subject of fracture of the upper cervical vertebræ in connection with the question of sudden death from unknown causes, is discussed by Dr. Alfred S. Taylor, in his *Manual of Medical Jurisprudence,* 2nd. Edit. p. 386 and p. 581.

cut through the spinal cord, and been stopped by the odontoid process, against the back of which it was found sticking, on examination after death. A fissure was also perceived running across the base of the process (Fig. 61). A female, with whom he was in bed, had been wakened before the shot was fired, and she stated that, notwithstanding the loudness of the report, the murdered man never stirred a limb, but seemed to continue his sleep undisturbed.

The same Museum contains a remarkable specimen of dislocation of the greater part of the atlas, including the articulating processes, both from the occiput and from the axis, with fracture of the odontoid process; followed by solid union of the displaced fragments. The patient, a farm-labourer, had been under the care of Mr. B. Phillips. He had fallen headlong from a hayrick; had been stunned for a short time, but then walked to the house of his medical man. He resumed his occupation in two days. A month after the accident he walked two miles to Mr. Phillips's house, and complained only of stiffness of the neck, which prevented him from turning his head. There was a swelling in the throat, supposed to be enlargement of the tonsils; his speech was thick, and he had some difficulty in swallowing. He lived for a twelvemonth after the accident, his death being caused by general dropsy. The specimen shows the odontoid process of the axis to have been broken at its base, and the atlas fractured across at the thin parts of its arch, behind the articulating processes. The anterior segment of the atlas, consisting of the articulating and transverse processes, with the arch in front for receiving the odontoid process, had been displaced from its situation between the occiput and atlas, and transported to the fore part of the body of the axis. The broken ends of the segment, behind the articulating processes, had become firmly united to the sides of the body of the axis, against which they abutted. Thus a ring had been formed before the axis, on the same horizontal plane; and as it had some resemblance to the foramen containing the spinal cord, the specimen had the singular appearance of being a single vertebra provided with foramina for two vertebral canals.

The mode in which the displacements shown in the specimen were produced, appears to have been as follows. The fracture of the odontoid process of the axis and that of the posterior arch of the atlas probably took place first. Now these fractures would have the effect of removing the chief impediments to the segment of the atlas situated between the occiput and axis being thrown forward out of its place. Next, as the patient fell from the hayrick head foremost, it may be inferred that, when he came to the ground, a powerful force would be directed on the cervical vertebræ in such a way as to compress the segment of the atlas on its upper and under articulating surfaces, and cause it to be shot, wedge-like, horizontally forward, and to be thrown over the edge of the axis, to lie between that bone and the pharynx. When the atlas had thus vacated its place, the condyloid processes of the occiput would settle down on the axis; and they would rest on it with comparatively greater security, owing to the odontoid process having been broken off. In course of time, new joints would be established between the occiput and axis.

It is much to be wondered at that an injury of such great severity as must have been inflicted to produce the effects exhibited in the specimen, especially considering its situation in reference to the spinal cord, should not have caused the instantaneous death of the patient. The only thing that can be noted in the way of explanation appears to be, that, from the theca near the seat of injury, namely, at the foramen magnum, being closely adherent to the vertebral canal, and from its being likewise thicker and firmer opposite to the atlas than lower down, that strength and stiffness of the membrane may have had some share in protecting the cord from being crushed, when the displacement took place.*

Of Bed Sores.—It has just been seen that when the spine is fractured high in the column, the chief danger to life is that caused by interruption to the breathing. But in whatever part it be broken, and however low, if paraplegia has been produced, the patient will be subject to the exhausting effects of sloughs and bed-sores.

The common situations for these sores are—1. The skin over the most prominent part of the convexity of the sacrum; 2. That over the tuberosities of the ossa ischii; 3. The skin over the greater trochanters of the thigh-bones.

The time varies at which the sloughs begin to form after the accident. Equal care being supposed to be taken in all to avert them, the differences may depend on the age, constitution and bulk of the patients. They generally manifest themselves about the fourth day; but they have been observed as early as the second. The first sign of a slough beginning is that the skin presents a white, sodden appearance; it then becomes brown and mottled, and the cuticle separates. In a short time, a patch in the centre turns black; the skin is then disintegrated, and ere long becomes pulpy and shreddy. The sloughing extends from the circumference indefinitely. If it stop anywhere, a line of demarcation will be observed. In some cases the destructive process is carried so deeply as to involve the muscles. After the slough has become detached, it is not uncommon to find the part of the sacrum over which it was formed in a necrosed condition. The vertebral canal has been opened in such circumstances, causing inflammation to spread to the membranes of the cord.

A remarkable feature in the character of these sloughs is the rapidity with which they form and extend; and that even in persons not debilitated by previous illness, but shortly before in robust health. That observation has induced some to believe that the chief cause of the production of sloughs, in cases of paraplegia from fracture of the spine, was a supposed defect of nervous influence, due to the destruction of the spinal cord. But, before accepting that as the only explanation, the peculiar circumstances of a patient suffering from the effects of a fracture of the spine ought to be considered. When a man has had his back broken, nothing is ever seen in the living body equal to the permanent fixedness of his hips and legs in the exact position in which they had been originally placed when he was first put upon his bed. There are three distinct causes for that absolute immobility. The most obvious one is his want of command over the muscles of the paralysed parts. The second is, that, from being deprived of sensation, the patient is unconscious of pain or irksomeness from always retaining the same position: he, therefore, does not desire change, or ask his attendants to shift his position. Thirdly, the fracture of the spine itself is a cause of his inability to move: he may possess sufficient strength in his arms for lifting or turning himself; but as the beam that connects the upper with the lower part of his frame has been broken, his efforts will be abortive; and if his nurse attempt to help him, the pain and additional injury to the part will make her desist. Accordingly, the patient continues lying—quite indifferent to, or ignorant of, the bad consequences—in one settled position all day, and all night, perhaps for several days consecutively. Hence, the whole weight of his hips will press with concentrated force on the integument which covers the most projecting points of his pelvis. The skin overlying the superficial, convex, and irregular surface of the sacrum receives the principal pressure. That compression interrupts the circulation: the blood which ought to go to the part is prevented; that which ought to be there is squeezed out; the vessels are tenantless. An additional evil remains: it is almost impossible, with the greatest care, to prevent a small quantity of urine from trickling into the bed-clothes; besides that, in spite of every attention, liquid fæces lodge about the anus, and are mixed with the urine; the skin of the nates becomes macerated in that noisome mess, the acrid fluid acting upon his sodden tissues like a caustic. It is not surprising, therefore, that, by the combination of an uninterrupted, inelastic, dead pressure of the skin against the sacrum, with the irritating influence of the wet bed-clothes, a portion of it should soon be converted into a slough. The subject is illustrated by observing the difference in the effects when the spine has become united. As soon as the consolidation of the column has taken place, the sloughs separate, and the sores fill up with granulations, and cicatrise, although there be no amendment whatever in regard to motor power or sensation. Now that improvement is to be ascribed to the opportunity afforded of turning the patient's body frequently, and performing the various offices of nursing more effectively than before, owing to the union of the fracture. The same is witnessed in persons affected with paraplegia from tumours within the vertebral canal, or from caries of the spine when anchylosis has taken place; in these cases, by moderate attention to nursing, sloughs or bed-sores may be easily averted, or healed up, if already formed.*

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* For Mr. B. Phillips's account of the case, see *Med.-Chir. Trans.*, vol. xx. p. 78. That gentleman presented the specimen to Sir Charles Bell.

Of affection of the urinary organs.—The debilitating effects of formidable bed-sores may be readily estimated. But simultaneously with these the patient has to encounter other serious dangers connected with the urinary organs. Owing to the bladder being deprived of sensation, and the muscular coat being unable to expel its contents, disease extends to the whole series of parts, including the kidneys.

1. The bladder becomes inflamed from over-distension. The patient being no longer prompted by calls to pass his water, and the detrusor urinæ having lost its power of expulsion, there is constant danger of the urine accumulating, and filling the bladder beyond its normal capacity. That risk is met by the surgeon drawing off the water at regular intervals. But, owing to the quantity of urine secreted varying at different times, and other causes, that mode of relief is an imperfect substitute for the natural one; and the walls become occasionally over-distended. Now the effect of over-distension is an excessive stretching and tearing of the tissues of which the coats are composed; and it is reasonable to suppose that inflammation should arise from that cause. When the viscus is similarly expanded beyond its ordinary dimensions in retention of urine from enlarged prostate, inflammation is a common consequence. 2. The frequent repetition of the introduction of the catheter, imperatively called for, is another cause: owing to the patient's insensibility he gives no token of being hurt, even when the instrument is used rudely, and the surgeon is apt to be betrayed into carelessness: but, whether the operation be performed gently or not, there is reason to believe that the repeated passage of the catheter brings on inflammation in the urethra and neck of the bladder.† 3. Within a few days after the

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* See *antea*, p. 378 and p. 391.

† The writer has read and heard of more than one case of false passages being made. The swollen condition of the penis, called priapism, has been attributed to the irritation excited by the introduction of the catheter; but it occurs immediately after the accident, and before an instrument has been used.

accident, varying from the second to the ninth, it is commonly observed that the urine, previously acid and clear, becomes alkaline and turbid; and the change is made known by the pungent ammoniacal smell. The turbid appearance is due to the addition of mucus; that increases gradually, sometimes to a large amount; and it becomes tenacious and ropy, so as to adhere to the bottom of the utensil. After a time, white matter, ascertained to be phosphate of lime, is found in the mucus. Blood is also sometimes combined with the other contents. That disordered condition of the urine generally lasts, in fatal cases, till the death of the patient. But not unfrequently its duration is temporary, and there is an alternation of periods when the urine is acid or alkaline. Cases are also met with in which the prevalent condition throughout has been that of acidity.

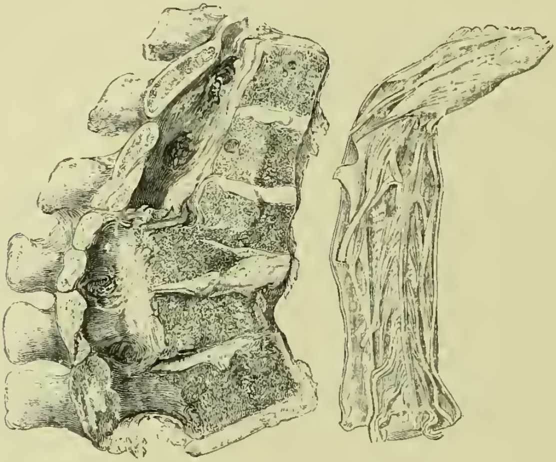
In explanation of the differences, it has been stated that the urine is always acid on first entering the bladder, and that the change to alkalescence takes place during its stay in the viscus. The theory is to this effect: it is supposed that when the bladder is paralysed, the mucous membrane is deprived, at the same time, of the peculiar property possessed by it of bearing to have in contact with it an excrementitious fluid, compound and acrid in its nature, like the urine. A mutual relation of that kind exists between all the hollow viscera and their contents; as the stomach with the gastric juice, the gall-bladder with the bile, the rectum with the fæces. If the relation be wanting—for example, if the urine be extravasated into the cellular membrane, or cavity of the peritonæum, structures not endowed with the property, sloughing or high inflammation will be the consequence. Again, if the urine be kept in a utensil, chemical actions, previously restrained, will be set up. It is conceived that, in paraplegia, the influence adverted to is no longer possessed by the mucous coat; and that the affinities which bind the various constituents of the salts of the urine are changed. Hence it is supposed that the urea separates into its original elements; the disengagement of ammonia explains the ammoniacal odour; and new combinations, leading to the formation of phosphatic salts, take place from the other elements let loose. Chemical processes such as these cannot, it is said, be carried on within the bladder without exciting irritation in its coats. Accordingly, inflammation falls on the mucous membrane, and extends to the walls generally. A superabundant secretion of mucus, of a tenacious, birdlime consistence, is the consequence; and the morbid action proceeds along the ureters, till the kidneys are included. In some cases, the inflammation is of such violence that portions of the mucous membrane are thrown off, with indescribably fœtid odour, as sloughs. In other chronic cases, again, calculi of phosphate of lime form both in the bladder and in the kidneys; and these set up fatal irritation in the organs generally.

A young man, who was under the writer's care in the Middlesex Hospital, had fracture of one of the dorsal vertebræ, and complete paraplegia, from falling off a tree. With difficulty he passed through the dangers of extensive sloughs on his nates; and after surviving for eight months, appeared to be recovering, with paralysis. For the greater part of that time the urine flowed continuously into an urinal, and the catheter was not used. Eventually, the urine became turbid and fœtid; and the patient died with symptoms of aggravated disease in the bladder. On the post-mortem examination, five phosphatic calculi, each about the size of a pigeon's egg, but of irregular, angular shape, and surrounded with mucus, were collected closely together in the lower fundus of the bladder, the internal coat of which was discoloured and shreddy. Calculi of the same kind were impacted in the calices, and contained loosely in the pelvis, of both kidneys. In this case, pain, which is generally the most prominent symptom of stone in the bladder, had been absent. Again, owing to the patient having been confined to bed, and the detrusor urinæ having ceased to contract, the calculi were not subjected to a rolling motion; they did not acquire, therefore, the smooth, rounded form, characteristic of urinary calculi. It is probable that the inflammation which supervened at last was occasioned by the stones having gradually become so large that they reached above the level of the orifice of the bladder, blocked it up, and so obstructed the flow of urine.

In another patient, the writer observed a remarkable peculiarity in the shape of the bladder, obviously the consequence of continual stillicidium urinæ. The patient had complete paraplegia from fracture in the dorsal region, and his water had flowed continuously into an urinal for several months before death. In the post-mortem examination, the bladder was found to be of the usual form and capacity at the lower fundus; but the upper fundus was closely and permanently contracted, so that the cavity was completely obliterated, and, to overcome the contraction, a boring action of the finger was required. It was obvious that, from the urine escaping through the urethra about as quickly as it entered the bladder, the cavity above the level of the orifices of the ureters could not be kept dilated.

Prognosis in paraplegia from fracture.—If a man be reported to have 'broken his back,' it is known generally to be one of the gravest of accidents. The first thing which will guide our opinion as to the probability of the patient's surviving will be the situation of the fracture. If it be below the level of the second lumbar vertebra, where the cauda equina alone is contained, it may be expected that the patient, even when the displacement is great, will retain motor power and sensation in his lower extremities, and that he will recover. Should the fracture be through either of the vertebræ in which the terminal portion of the cord, surrounded by the roots of the nerves, is situated, the paralysis may be partial; or, though complete, the patient may have some hope of recovery. When fracture occurs in the dorsal region, the prognosis is unfavourable in all cases; but more so the higher the fracture is situated, in correspondence with the increased number of intercostal muscles thrown out of action in breathing. In fracture of the cervical vertebræ the cord is generally crushed so thoroughly and the paralysis is so general that, instead of entertaining the question of the patient's recovery, the surgeon counts by days only how long he may live. The sole hope that he clings to is the chance that the spinal cord may have been so slightly injured as to have produced only transient paralysis. If the fracture has been at the summit of the spine, in the atlas, or processus dentatus of the axis, unless the patient should escape in the remarkable manner related in Mr. B. Phillips's case, he will be dead before the surgeon can reach him.

Fig. 62.



The left-hand figure represents the section of a spine which had been fractured in the dorsal region, eight months before death. The fragments have become firmly united. One of the intervertebral foramina has been obliterated. The figure on the right is intended to show the disorganised and atrophied condition of the cord, in the same spine, at the seat of injury. The case is briefly referred to on the previous page. Both preparations are in the Museum of the Middlesex Hospital.

Case of recovery from fracture of dorsal vertebræ.—The following case is inserted in this place, as it illustrates some of the subjects discussed in the preceding pages.

Mr. R., thirty-two years of age, from the West of England, consulted the writer in the summer of 1860. When about nineteen years old, he fell, with a branch of a pear-tree on which he sat astride, a height of thirty feet. He was found to have fracture of the spine, between the eighth and tenth dorsal vertebræ, and complete paralysis of the lower extremities and of the bladder and rectum. At first, his life was despaired of during several weeks, on account of immense sloughs on the nates, and disease in the urinary organs, induced by the paralysis. At length the sores healed; and as promoting that, he attached great value to the use of india-rubber water-pillows, which he began to use a fortnight after the accident. These pillows he has occasionally tried to give up; but as soon as he did so, new sores formed; and he employs them to the present time, whether sitting or lying. The urine was drawn off by the catheter twice daily for three months. At first, it was extremely offensive, and loaded with ropy mucus. Subsequently, the water began to dribble away, and the introduction of the instrument was discontinued. Though there is still incontinence of urine, the bladder gets filled: he is made aware that it is distended by what he describes as a peculiar tremor felt at the pit of the stomach: he then squeezes the abdomen in the region of the bladder, with both hands, and so causes an increased quantity of urine to be expelled: the above proceeding he repeats about every third or sixth hour. During the first year he was much inconvenienced by constant or frequently recurring involuntary discharge of the fæces: since then he has had the same want of control over the passage of the stools; but the act has been performed at distant intervals, the ordinary period between them being seven or nine days; sometimes the interval is a fortnight: a short time before each action he experiences a sense of heaviness in the head, and has slight flushing of the face; and the stool which comes is immensely large and of nearly solid consistence. It was not till six months after the accident that his hips were sufficiently sound for him to sit up and be wheeled in an invalid-chair. The legs are now entirely devoid of sensation; and during the first eighteen months they were perfectly motionless. After that the effects of galvanism were tried, and ever since both limbs have been subject to sudden, and sometimes violent, startings: these are commonly excited by touching, or changing the posture of the legs; but they take place when he is lying quiet, without any apparent cause; within the last six years the strength and frequency of the convulsive actions have abated, and they have never caused pain; but, as they are both inconvenient and disturb his sleep, he is accustomed to fasten his feet by straps to the sides of the bed, by which they are counteracted. Since recovering from the dangers immediately following the accident, his health has been almost uninterruptedly good. His lower limbs, from the hips downwards, are atrophied, and the joints of the ankle, instep, and toes, stiff and distorted. But in the upper part of his body he is stout and powerfully built, the muscles of the shoulders and arms being developed to a degree of magnitude seldom seen even in the most athletic. He drives himself in his open carriage. He was not fatigued by his long railway journey. During his stay in town he paid visits to the Crystal Palace and other show-places. He is provided with a mechanical bed, combining all the ingenious contrivances of its most improved construction.

Treatment of fracture of the spine.—Should the surgeon happen to be at hand when the accident has just occurred, his first object ought to be to guard against motion of the spine, while transporting the patient to his home. Before allowing officious persons to lift him from the ground, provision ought to be made for his being borne on a door, shutter, or the like; otherwise there will be an aggravation of the crushing and tearing of the cord. If from the seat of pain it appear that the fracture is near the neck, a sack or pillow-case ought to be filled with sand; by heaping which about the head, it can be kept steady.

When the clothes have been *cut* off (to avoid motion) and it has been found that the fracture, or fracture and dislocation, is accompanied with considerable irregularity and projection of the processes, it is necessary to bring the parts into a more favourable position for future union. But the employment of much force is to be deprecated; a gentle stretching of the body, steadily continued, may be had recourse to; but, except in rare cases, a slight change of the posture of the patient is all that is needed; when laid flat on his back, the parts tend of themselves to come into correct apposition.

In selecting an appropriate bed some foresight is wanted. The one which is to be preferred above all others, is a properly-constructed water-bed. If an invalid-couch, on the principle of Earle's, be procured, it will afford numerous facilities for nursing; by slightly bending its various joints, the trunk and limbs of the patient can be placed in a favourable position for steadying the spine at the seat of fracture: the direction of the pressure on the hips can be gradually changed from time to time; while conveniences for removing the evacuations without the necessity of lifting the patient from the bed are added. Should a bed of that kind be too expensive, the next to be preferred is a narrow one, rather low, with boards in place of sacking, and two or more elastic, yet firm, horse-hair mattresses. Mackintosh cloth, and over it a draw-sheet, should be placed under the patient's hips. Water-pillows, and common feather, or horse-hair pillows, lined with oil-silk, should be bountifully provided.

Experience shows that the application of leeches, or cupping, is not called for; that patients with paraplegia do not bear loss of blood; and that, instead of subjecting them to frequent motion in applying local remedies, it is best to preserve the spine in perfect repose.

No delay ought ever to be allowed in drawing off the urine, by the introduction of a full-sized catheter into the bladder. The patient may not have passed water for several preceding hours; he has no call to do so; and delay may be attended with injurious over-distension of the coats of the bladder. It ought to be remembered that as the patient will give no token of pain, however much the instrument may injure him, the operator ought to pass it with all gentleness. Twice in the twenty-four hours is commonly considered sufficiently often for the introduction of the catheter. But if the kidneys secrete abundantly, or if the urine become turbid and ammoniacal, a more frequent introduction may be expedient. In the latter case, the bladder ought to be washed out daily with tepid water, acidulated with nitric acid. Mineral acids may also be given internally. As incontinence of urine frequently goes along with retention, and the patient's linen is in danger of becoming wet, he ought to be furnished with an urinal; but due attention requires to be paid to that utensil, lest, owing to the insensibility of the parts, it be allowed to run over, or be upset. When the period arrives (if the patient should live) at which the neck of the bladder offers no resistance to the escape of the urine, and the latter continually, runs off as water from an over-filled cask, watchfulness on the part of the attendants is more essentially required, to prevent the bedding from becoming soiled. The constant use of the catheter will be no longer called for; but it may be proper to inject the bladder occasionally, to remove sediment that may have collected.

In the management of the bowels, it may be assumed that they will be costive in general. When the sphincter ani relaxes, and abandons its opposition to the escape of the stools, the contents cease to be discharged at regular times, as during health: they pass out, without warning, at any unlooked-for moment; accordingly, however unremitting the nurse may be in her attention to cleanliness, her efforts will be defeated. But at a subsequent period, the stools are delayed in the great intestine; they become compact; they are discharged at long intervals; and the inconvenience resulting from their passing involuntarily is greatly abated.

Treatment of sloughs and bed-sores.—It has been stated above that the parts of the hips most liable to the formation of sloughs are those exposed to greatest pressure, and to continual irritation from lying on bed-clothes saturated with urine and liquid fæces: that it is the skin over the sacrum, and over the tuberosities of the ischia, which gives way first. In order, therefore, to prevent the formation of sloughs, or to promote their cure, the chief objects are, first, to remove pressure; secondly, to insure cleanliness. The main obstacle to gaining these two ends, at the commencement of the treatment, is the injury committed on the fractured portion of the spine, by moving the patient's body; every time that is done, a jar is communicated to the broken surfaces; a grinding of one upon the other takes place; pain and inflammation are excited; and the process of union is interrupted. Yet, without frequently turning and lifting the patient, it is impracticable to ward off pressure, or keep the hips clean and dry. It being required, therefore, that the position of the hips should be often changed, the attendants ought to be instructed how to accomplish it with the least danger. Small pillows ought to be gently insinuated, at different times, under the hips. When compelled to turn the patient round on one side, care should be taken that the shoulders and upper part of the body are rotated, at the same time, in a corresponding degree.

As a means of protecting the skin from the chafing of the wet bed-clothes, much good might be expected from painting the surface repeatedly with collodion; but as the application would require to be renewed about three times daily, and that would necessitate the patient's body being turned on each occasion, it can only be used partially at first; subsequently, if the fracture unite, it will be found of great service. Advantage may be gained by the ring-pillow being placed under the hips, so that the central hole may come opposite the sacrum, and the weight fall on the fleshy parts on each side. Or a plaster spread on thick material (as two layers of wash-leather, including between them a layer of felt, or amadou), with a hole cut out in the centre, may be stuck on the part which it is desired to defend. Lastly, the india-rubber water-pillow, of a size adapted to the hips, and containing a little air as well as water, may be used with advantage. For keeping the bed-clothes dry, frequent changing of the draw-sheet is the chief resource; but an additional measure may be resorted to: if the patient's thighs be kept apart, and the knees slightly elevated on a pillow, a large porous sponge, or some tow, previously wetted and wrung, wrapped loosely round with gutta-percha, may be inserted deeply in the perinæum; the excretions will thereby be caught, and be readily removed often. If, notwithstanding every care, a portion of the skin lose its vitality, and the cuticle begin to peel off, the amount of destruction may be limited by dressing with the linimentum terebinthinæ. When the part is more decidedly mortified, with foul discharge, cotton-wool saturated with balsam of Peru is a good application; and over that should be laid either a firm, thick linseed poultice, or a compress of cotton-wool, moistened with yeast. For cleansing foul or sloughing sores, nothing surpasses the carbolic acid lotion. Cotton-wool has the property of clinging to the skin when wet, and so prevents the under-dressing from being shifted. As the slough loosens, it ought to be clipped away with scissors. Should the surface happily become clean, and healthy granulations spring up, water-dressing, with a continuance of the measures for protecting the hips, will best favour the cicatrisation.

On trephining the spine.—When it is proposed, in a case of fracture of the spine with paraplegia, to trephine at the seat of injury, the object is to elevate or remove any fragment of bone that may project into the vertebral canal and compress the cord. It is supposed that, by taking off the compression, the cord will recover its lost functions, and the cure of the patient be promoted.

The operation has obviously been suggested by the analogous one performed on the head. When a man has fracture of the skull, and a portion of bone is driven in upon the brain, the surgeon applies the trephine, raises, or picks away the depressed piece; and, if the case be favourable, the patient will become conscious, recover power over his paralysed side, and eventually get well. But the analogy between the two cases, in various points, does not hold good.

1. The relation of the skull to the dura-mater and brain is widely different from that of the vertebral canal to the theca and cord. In the former, the structures are in close apposition: in the latter, the canal is separated to a considerable distance from the theca, and the theca from the cord. The effect of compression by a projecting portion of bone must, therefore, differ greatly in the two cases.

2. Owing to the small size of the cord, compared to the

brain, an injury inflicted on it, such as would damage the brain only to a slight degree, might destroy its structure throughout its whole thickness, and deprive it of all its functions.

3. In the skull, fracture with depression is the result of direct force, as from a blow. In fracture of the spine, the force is generally indirect, as from a heavy body descending from a height on the head and shoulders. Now the peculiarity of the latter is that, after the breach has been made, the force does not cease to act; the weight continues to bear upon the fragments at the seat of fracture, and so increases the displacement. The degree to which that displacement has taken place cannot be judged of by the appearance of the spine subsequently; for, owing to the elasticity of its structure, it rebounds, after having been violently bent, nearly to its original straightness. The spinal cord, however, must at the moment of breakage have undergone a severe crushing of its whole substance, at the seat of fracture. Accordingly, in performing the operation of trephining, in the two cases, there will be this great difference—namely, in operating upon the head, the surgeon will expect, after removing the depressed fragment of the skull, to find the brain throughout sound; but in operating on the spine, he will find the part of the cord situated between the fragments broken down into a soft pulp; incapable of resuming its functions, after the cause of compression has been removed.

4. In fracture of the skull requiring the trephine, the surgeon has to cut through the scalp only, in order to reach the depressed fragment. In fracture of the spine, he will be obliged to make an incision, in the line of the spinous processes, above an inch deep, and not less than six inches long, through skin and muscles—to clear the trough of the spine of its tendons and muscular fibres—and to break up the posterior arches of the vertebræ at the seat of fracture, by means of trephine, saws, bone-scissors, levers, and forceps. When he has forcibly detached the spinous processes and laminæ, and exposed the cord and sheath within the vertebral canal, he will probably learn that the fragment of bone chiefly concerned in compressing the cord is a portion of the body of one of the vertebræ, situated at a part in front quite inaccessible.

This formidable operation will have the effect, not merely of converting a simple into a compound fracture, but the bottom of the deep, ragged wound will be in communication with the interior of the vertebral canal. Hence, if the case follow a common course of compound fractures, and suppuration supervene, the pus that is formed will have free access to the space between the walls of the canal and the sheath of the cord; it may, therefore, penetrate to some distance, each way, from the seat of fracture: and it is not improbable that, if the operation had been successful in causing the functions of the cord to be restored by the removal of the compressing fragment of bone, these functions would soon be lost again by the inflammation set up in the cord and its membranes from the presence of the pus around.

Again, let it be considered what the effect will be of dividing, in the course of the operation, the muscles and their tendons that may be in the way, and of removing portions of the posterior segments of the vertebræ at the seat of fracture. These are the principal structures by which the broken ends of the upper and lower fragments of the spine are held together. Consequently, when they are cut and taken away, the mobility of the fractured part will be greatly increased. When any attempts, therefore, are made, with the view of defending the hips from bed-sores, to vary the position of the patient by turning him round in bed, the fragments will roll freely on each other, there will be a grating of their surfaces; the attempts will be unsuccessful; and the cord will inevitably be injured.

From what has been stated in previous pages, it may have been seen that, except in those cases of fracture high in the spine in which respiration has been interrupted, the paralysis is not the direct cause of the fatal termination in cases of fracture generally. The chief dangers to life arise from extensive and exhausting sloughs and bed-sores, morbid conditions of the bladder and urinary organs generally, and, in a certain degree, from derangements of the bowels. These are indirect effects of the paralysis. But if they be overcome, the mere loss of motion and sensation in the limbs, and inability to control the actions of the bladder and rectum, will not destroy life, or be inconsistent with the patient enjoying good health.* The practical deduction from this observation is, that the principal aim, in the treatment, ought to be to avert those bad consequences; and endeavour to preserve life, without incurring formidable risks in expectation of getting rid of the paraplegia.

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* The case related at p. 403 is a favourable illustration of what is stated in the text.

Moreover, numerous examples have been adduced to show that, especially when the seat of the fracture is at or near the dorsi-lumbar region, complete recovery is a frequent event, the patients having become strong on their limbs, and able to resume their occupations. Accordingly, in that situation in particular, the operation of trephining ought to be avoided.*

ALEXANDER SHAW.

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* On the question of the propriety of trephining the spine, in cases of fracture, with paraplegia, see the Report of a discussion on the subject, at a meeting of the Medical and Chirurgical Society, in the *Medical Times and Gazette*, for December 9, 1865.

See observations on the same subject, by Mr. Jonathan Hutchinson, in a Clinical Lecture on Dislocations and Fractures of the Spine, in the *London Hospital Reports*, vol. iii. p. 357.

See also the same question discussed, by Mr. Le Gros Clark, in his Lectures delivered at the College of Surgeons, reported in the *British Medical Journal*, July 17, 1869.

INJURIES OF THE FACE.

THE human face, the front and most exposed part of the body, would be more frequently the seat of injury were it not for its comparatively small size, the great mobility of the head, and the mechanically protective articulations of the forearm and hand. Of the first it is unnecessary to speak. As regards mobility, the head can bend backwards and forwards, and also rotate in no small circumference upon a horizontal plane; and to this the effect of the general mobility of the vertebral column is to be added. The obliquity of the inferior extremity of the humerus from without, downwards and inwards, brings the hand in flexion immediately in front of the mouth. With these means of guard, the head and face, guided by the eye, readily escape common accident; and those injuries which befall it are for the most part sudden, and often violent.

The skin of the face is not quite similar to that of other parts of the body. It is more abundantly supplied with minute vessels, which partake of the character of gland-vessels, in being able to propel, without the heart's influence, an additional amount of blood to the surrounding tissues. The nerves, the sebaceous, and sudoriparous follicles are highly developed, and the dermal structure is intimately united to the layer of subjacent muscles, whose action, impressing lines upon the skin through the subcutaneous adipose layer, gives impress to the features, and imparts the stamp of character to the individual. The bones of the face lack the density of the bones of the extremities; they are either thin and paper-like, or thicker and spongy; but in both instances vascular, and little prone to exfoliation from common causes. They bleed when cut; they yield to distension, and are capable of recontraction; they are subject, moreover, to the morbid changes, such as are witnessed in softer tissues, and they unite readily when broken. Injuries to the face, then, may be appalling to the bystander, but they excite far fewer feelings of dread in the mind of the surgeon. A soldier in warfare receives a sabre-cut across the face; the wound may gape and look ghastly, but it is in general curable. An artizan is struck with a winch-handle violently upon the cheek; he is seen with distorted features and in wild delirium; but the stress of the injury is recognised as limited to the face: experience shows that the commotion of the brain will subside, and teaches that the prognosis is generally favourable.

Erysipelas is an accident which not uncommonly complicates these cases. Commencing about the seat of injury, it spreads over the entire head, where its presence is dangerous from the proximity of the brain, and the close vascular connection between the parts within and without the skull.

But, these evils guarded against and avoided, there is still, in the event of recovery, the chance of deformity, of unpleasantness of expression, or of impairment of movement in parts essential to the integrity of an important organ, such as the covering of the upper lid to the transparent cornea of the eye. To all these points the surgeon must direct his attention in the selection of such measures from the commencement as are best calculated to insure relief.

Bruises.

Blows on the face are commonly followed by extravasations of blood, which, as in the familiar instance of a black eye, are seen, in their various phases of transformation and absorption, passing through the shades of colour from deep brown, brownish or yellowish green, pale straw hue, to the natural aspect, through the thin integuments of the face. It not uncommonly happens that, in connection with the bruise of the skin, there is extravasation of blood under the conjunctiva, or in the anterior, or even posterior chamber of the eye. These injuries are interesting, both pathologically and surgically. In the first instance, as showing what becomes of extravasated blood, and how soon it may become absorbed. In the second place, as affording an opportunity of testing how far we are in the possession of means calculated to assist and to expedite the efforts of nature.

I believe that, unless circumstances of unfavourable character interfere with the processes of repair, the rapidity with which effused blood is removed by the unaided action of the absorbents has been much under-estimated; it seems to be the very first step towards recovery, and its retardation implies the existence of some disturbing or morbid influence.

In 1837 a boy aged ten was brought into St. Bartholomew's Hospital with a bruise on the brow, and with effusion of blood into the anterior chamber of the eye, from a blow, to such a degree that neither pupil nor iris could be seen. During the course of the night so large a quantity of the blood had been absorbed from the eye as to leave the pupil visible; and at the end of the sixth day from the accident the anterior chamber was clear, there being only a stain of blood upon the surface of the iris, indicating, in all probability, the exact spot where the blood-vessel had given way.

So in bruises of the skin and subjacent parts, the removal of effused blood commences immediately upon the receipt of the injury, and goes on with a rapidity proportioned to the healthy state of the individual and the activity of circulation in the surrounding parts. Pugilists, who are brought into high condition by the usual system of training, recover from the bruises which they sustain in the exercise of their calling in from six to nine days. 'However much a man may be beaten about the head,' explained one of the fraternity to me, 'he is "himself again" in little more than a week, provided he keeps from drink, and takes an occasional dose of opening medicine.' Experience has shown these men that they may take animal food with impunity, but that stimulants in the shape of drink interfere with and retard the removal of the bruise. The only exception to this statement respecting rapid absorption, is in the case of the effusion of blood between the conjunctiva oculi and the sclerotica. Here a space of four or six weeks may be necessary for the removal of the stain; but, then, we must remember that in the normal state there are but few vessels of any kind engaged in active work in either tunic. We do not in the present day bleed a patient in consequence of a bruise; neither do we employ stimulating lotions nor frictions to the affected part. An evaporating lotion may be used if there are heats, and the patient feels the application grateful; but the best treatment consists in abstinence from drink (unless under exceptional circumstances), in rest, and the occasional administration of aperient medicine. I have not witnessed any clearly-marked beneficial effect from the employment of tincture of arnica, as recommended by many surgeons. It may be used in the same strength as spirits of wine, in the proportion of one part to eight or ten of water, as a lotion, and it will at least serve to occupy the patient's mind. But the stories of its almost miraculous powers are without foundation, and exist only in the imagination. It may be rubbed into the bruised part, either undiluted, or mixed with an equal part of water; or the patient may use Friar's balsam, or any stimulating liniment instead. These applications serve only to excite the circulation, a measure usually unnecessary as regards the head and face, and capable, if in excess, of inducing a result totally opposite to that for which it was intended.

The practice of making a puncture into parts distended with extravasated blood, in order to preserve the vitality of the skin, is rarely necessary in injuries to the face. The only parts to which such a measure can ever be applicable are those where the subcutaneous tissue is very loose, and easily distended, the skin being of extreme tenuity, such as the upper eyelid; but even here we have rarely occasion to do so.

The question of rapid or of slow absorption of blood is one of practical importance; for by its proper solution we may justly estimate the progress of the case. In contrast with the rapid recovery of the pugilist, we may put the case of a pallid, feeble, and under-fed woman, bearing upon her person the marks of ill-usage. It is no uncommon thing to see in such a person the mottled-yellow ring around the eye, telling its tale of the blow inflicted by a brutal hand, persisting, with but little change, for many weeks. Under such circumstances the treatment would be different, a more generous diet being advisable. But even here I question much the value of stimulating or other local applications. In the forehead, extravasated blood presents itself under two different conditions. There may be a simple cutaneous bruise, or there may be a collection of fluid blood under the occipito-frontalis. We have already discussed the former species of injury. The latter may be dismissed with a few words, as it will be found more thoroughly treated in the essay on INJURIES OF THE HEAD (p. 254). One of the larger vessels of the forehead, bruised or otherwise damaged by a blow, gives way some days after the accident, and pours forth a considerable quantity of fluid blood. An examination conveys to the hand of the surgeon the sensation as if there were a circular depression of the skull surrounded by a sharp ring of bone. The explanation of this feeling is not obvious; it is in no way connected with the composition or the coagulation of the blood, for it is felt whenever fluid in moderate quantity is contained in a yielding yet thick-walled cyst. I have noticed it frequently in the examination of chronic abscesses in various parts of the body, such as the buttock, arm, or knee. Blood thus effused may slowly increase, from the fact of the vessel remaining open, and bleeding subcutaneously; or the bleeding may cease, when changes commence calculated to remove the fluid. If, at the expiration of some weeks, an opening be made through the skin (a practice by no means generally to be recommended), a thick brownish-black fluid escapes, composed of blood-discs, albumen, and water. The absorbent vessels seem to remove the greater part of the fluid material, and either to remove, or to deprive of its natural properties, the coagulating element of the blood. If, under the circumstances of an injury, coagulation should take place—an event which must happen speedily, and before the absorbent vessels have had time to act on the blood, or else not at all—the clot acts as a foreign body, and will excite, especially in persons of unhealthy constitution, inflammation and suppuration, under which processes it will be discharged.

In these cases we again witness from time to time the action of causes which retard the absorption of blood. Let the patient pursue his usual habits, and take the customary amount of stimulants; the integument covering the swelling becomes hot and puffy, and the blood beneath either remains the same, or even increases in quantity. Let the patient adopt another course, namely, keep himself quiet, avoid stimulants, be moderate in his diet, and keep the bowels open, and the swelling, which was enlarging, first becomes stationary, and then disappears.

A boy aged seven was struck, July 1, 1838, on the right temple, towards the outer angle of the eye, by a stone, which was thrown at him by another boy in anger. A small wound was inflicted, which speedily healed; there was scarcely any bleeding at the time. The lad pursued his usual habits, and, a fortnight after the accident, found his head heavy and uneasy, although free from pain. The mother detected, in the situation of the cicatrix of the wound, a soft swelling, which increased in size until he was brought to St. Bartholomew's Hospital, where he was admitted July 19. There was a large fluctuating and irregular swelling caused by the elevation of the integument by fluid. The sensation of 'depression of bone' was communicated to the fingers. He was ordered aperient pills, and a cold lotion was applied to the head. On the 23rd of the month, no change being noticed, a puncture was made, when about four ounces of dark-coloured fluid blood escaped. The peculiar sensation resembling depression of bone was yet more evident. In three days he was convalescent, and discharged well towards the end of the month.

After very severe injuries involving fracture of the skull and injury to the brain, blood-stains and ecchymoses about the eyes remain unchanged for many days, or even weeks. Their existence is merged in the greater injury, and they are only important as a signification, by their persistence in doubtful cases, of the existence of some serious complications. After severe injuries to the great nervous centres, all vital processes are depressed and in part suspended.

We read of bruises, wounds, and other injuries of the frontal, and sometimes of the infra-orbital nerve, followed by amaurosis; and authors have endeavoured to explain the connection between the two. I have seen both nerves divided, and otherwise injured; the frontal nerve frequently, in cases of surgical operation and accident, and no instance ever came before my observation in which the injury to the nerve seemed to exert the least effect upon the organs of vision. A severe blow with a stick or sword upon the brow may be followed by immediate blindness, whether it divide the frontal nerve or not. But, then, the loss of vision is due to concussion of the retina, to rupture of the minute blood-vessels which ramify in that delicate nerve-layer, or to some other internal disorganisation; and we must in this way explain the case which Petit brought before the Academy of Surgery, namely, that of an officer who became completely amaurotic in consequence of a sword-wound in the eyebrow. To this same opinion the late Mr. Tyrrell inclined; he denied the existence of sympathy productive of such serious results between the fifth and the optic nerves, and referred the loss of vision to concussion of the retina. In the same way, I question the accuracy of the observation by Mr. Wardrop, that a partial, but not a complete division of the frontal nerve will sometimes produce amaurosis; and likewise the advantages of the method of treatment founded on that opinion, namely, to cut down and completely divide the nerve in question. 'I have met,' says Dr. Hennen, 'with one or two cases of amaurosis from wounds of the supra-orbital nerve; the perfect division of the nerve produced no alleviation of the complaint; but after some time, the eye partially recovered.' 'When defective vision follows a wound in the forehead,' said the late Mr. Guthrie, 'the only hope of relief, that we are at present acquainted with, lies in a free incision down to the bone, in the direction of the original wound; and even of the efficacy of this, I am sorry I cannot offer testimony from my own practice, *having failed in every case in which I tried it.'*[*] It is not easy to explain Vicq d'Azyr's experiments upon this subject. He laid bare, in a variety of animals, the frontal and superciliary branches of the fifth pair; he bruised and tore the exposed nerves, and convinced himself that this was speedily followed by blindness.[†] Now I divided the frontal nerve in two rabbits, in the month of February 1839, in order to verify the former experiments. After bruising and cutting the nerves in more places than one, I allowed the wounded parts to heal. No sensible effect was produced in the vision of the animals. In the summer of 1857, I assisted Sir W. Lawrence in the operation of dividing the infra-orbital nerve in a lady, of middle age, who had been a most severe sufferer from neuralgia. The sight remained the same, although the severment of the nerve-fibres in that situation is attended with a considerable amount of bruising.

But the use of the ophthalmoscope renders the diagnosis in those cases far more accurate and certain than in former times; and for the mode of its application, the reader is referred to the essay on DISEASES OF THE EYE.

A divided nerve unites as readily as any other organised structure; and the usual functions are restored when the connecting processes are completed. The nerve-fibrils pass through the effused fluid, and adapt themselves accordingly. Mr. Quekett, of the Royal College of Surgeons, possessed a specimen showing this process of union; and of its completeness we have abundant illustrations in cases of accident to other than the frontal nerve. The external popliteal nerve is sometimes cut through by the surgeon, in the division of the tendon of the biceps flexor cruris. The loss of sensation and motion, which is the immediate result, to the great dismay of the patient, is after some weeks completely restored.

WOUNDS.

The treatment of wounds of the face consists, as in the case of wounds in other parts of the body, in holding the divided surfaces in apposition until nature has had time to throw out a new connecting medium; only, in the face, more than usual care is required to maintain the parts in their exact normal relation. Let us imagine the unpleasing effect produced by the imperfect adjustment of a divided eyebrow. Sir W. Lawrence once had to reopen a healed but badly-adjusted wound in this situation, in consequence of the unpleasant expression it conveyed to the features, and to cause it to reunite in a more accurate manner. Wounds of the eyelids, particularly when attended with loss of substance, may be followed by eversion or ectropium; and wounds of the nose and lips, badly treated, may injuriously affect the functions of the organs of which they are the instruments. I cannot understand the 'immediate union' of Dr. Macartney; that is to say, 'that the divided blood-vessels and nerves are brought into perfect contact, that union takes place in a few hours; and as no intermediate substance exists in a wound so healed, no mark or cicatrix is left behind.' The union of divided surfaces, without the assistance of a new connecting medium, appears to me an impossibility. But the surfaces of a wound may be so accurately brought together, that the thinnest possible layer of connecting material may suffice for the reunion of the cut parts; in which case no evident cicatrix will follow. In all cases, therefore, whether we employ plasters or sutures, our endeavour should be to hold the wound together until the natural union by effused lymph is sufficiently strong to dispense with artificial assistance.

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[*] *Lectures on the Op. Surg. of the Eye*, p. 102, 1823.

[†] *Journal Complémentaire des Scien. Méd.* vol. xliv. p. 201, 1832.

A clean cut on the forehead does not always need a suture; the necessity depends upon the gaping of the wound. If, as is commonly the case, the edges keep in apposition, a few strips of plaster are all that is required: and let not the surgeon remove them for some days, unless heat and swelling supervene. Nothing interferes so much with processes of repair as constant changes of plaster, washings, and examination; a wound heals readily under an incrustation, or a hardened clot of blood, if left to pursue its own course, in a healthy subject. The practice of the antiseptic treatment of wounds is here wholly uncalled for. The great point is to surround the patient with unvitiated air.

Wounds involving the eyebrow should always be united by a few points of the interrupted suture, care being taken that the cut edges are quite clean. The shape of the eyebrow should be considered, and the first suture should be so inserted as to prevent any irregularity in that important feature. As regards division of the upper eyelid, an accident comparatively rare, no definite rule can be laid down. The part may be united by suture to the integument of the brow, if torn or separated therefrom; but the whole thickness of a divided eyelid should not be transfixed by a suture, one part of which must of necessity press upon and irritate the globe of the eye. Generally speaking, the prominent and convex globe forms an excellent support to the divided lid, and a few thin narrow strips of plaster, passing transversely as regards the wound, covered by others which, applied vertically, strap the lid down, and prevent the patient opening the eye for a few days, are quite sufficient. In some severe cases, the swelling about the brow and cheek has been so great, that the lids have remained closed for several days: under such circumstances, the application of a damp cloth is all that is needed. Hare-lip pins are out of place in wounds of the eyebrow; the desired end can be obtained, doubtless, by their means; but the proceeding is unnecessarily irksome, and possesses no advantages over the suture. The metallic suture should be used, if the surgeon happen to possess the necessary material; but for all usual emergencies a small needle, slightly curved towards the point, armed with a fine round silken ligature, will be found sufficient. There is no necessity for the patient to have the face constantly covered with a wet cloth. He may consult his own feelings; and the surgeon may remember that the process of union goes on most favourably under the thin dry line of blood marking the well-adjusted wound.

A vertical wound of the upper eyelid, passing through its whole thickness, the edges of which have cicatrised separately, leads to a deformity which has been termed *coloboma.* At the present time, however, this word is generally used to designate the congenital variety of the deformity. It may be rectified by an operation similar to that for hare-lip, excepting the employment of a hare-lip pin. A sufficient amount of union may be maintained by fine sutures, and the closure of the lid over the globe of the eye effected by strips of plaster. 'I have seen a case,' observed Sir W. Lawrence, 'in which a horizontal wound of the upper lid having been neglected, a sort of button-hole was formed, from the edges not having been kept in apposition; what was worse, accretion of the conjunctival surface of the palpebra to the globe had taken place, and the lid hung so much over the globe as to render the eye almost useless.' I have seen the same under circumstances of disease, where ulceration of the eyebrow and upper lid has ensued from syphilitic periostitis of the frontal bone. In such cases, the amount of disease still going on, or liable to return, renders operative interference unadvisable.

As regards wounds of the external ear or of the nose, the rule is absolute in surgery, that, whatever be the amount of injury, the parts should be carefully cleaned, replaced, and held in apposition by a few sutures and fine strips of plaster. Results which surprise even the experienced are thus obtained in the most unpromising cases; and the deformity is comparatively inconsiderable.

We read of cases of the division of Stenon's or Wharton's duct, of the establishment of a salivary fistula, and of the necessity of a plastic operation. The subject will be more fully discussed in the article on PLASTIC SURGERY. But I have never seen a simple wound of the face followed by the accident here referred to. Monro states that the duct has been wounded by the surgeon's lancet; and Desault, that it has been ruptured by a blow; and the latter gives minute directions, which are commonly quoted in surgical works, as to the mode in which the continuity of the canal is to be reëstablished and maintained. He recommends the introduction of a seton through the canula of a small hydrocele trochar into the mouth; the wound to be dressed daily, lint and a compress being applied to the cheek. Those who wish the details of this operation may consult *Œuvres Chir. de Desault*, par Bichat, t. ii. p. 221. I have had no experience of the use of the actual cautery, nor of the employment of a wire heated by an electric battery in these cases, although such means have proved of great avail in the closure of fistulæ in other situations. Rodolfi gives the particulars of a case in which he closed the opening by means of collodion.*

Wounds involving the whole thickness of the lip are usually united by the hare-lip pin and sutures. In all cases it is important to preserve the line of red margin to the lip; and this is best effected by a very fine needle and suture. But the metallic suture introduced by means of Simpson's grooved needle possesses the advantage of exciting so little irritation, that four or five days may elapse without any surgical interference. The wound should then be held together by fine strips of plaster passing round the entire head, by which the traction on the newly-formed material is prevented. An instrument for pressing together the cheeks has been invented for the same purpose. Collodion is rarely used as an application in wounds of the face; it drags too forcibly and unequally on the surrounding structures, and presses the blood from the capillary vessels, by which the process of repair is retarded.

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* *Gazz. Lomb.* iii. 1854.

Foreign bodies are occasionally introduced, more particularly by children, into the ear and nose. They should be removed from both situations, provided this end can be accomplished without pain to the patient, and with ease to the surgeon. But when it is remembered that, if left alone, the foreign body generally becomes loosened, and escapes without surgical interference of any kind, we have a very strong argument against the adoption of any means involving suffering. No cases similar to those related by Acrel in 1778, and by Morgagni and Valsalva, of worms making their appearance in the auditory passage, have been noticed of late years; surgeons have not been called upon to treat cases of convulsions dependent on such causes; and the practice of injecting the distilled water of St. John's-wort, in which mercury had been agitated, for the purpose of destroying the worms which remained, has gradually fallen into merited disrepute.

Mr. Samuel Cooper saw the case of a child aged two years and a half, into one of whose ears a pebble, and into the other a French bean, had been pushed by another child, and remained there ten months, causing complete deafness and extreme suffering. These bodies were removed by the forcible injection of tepid water and the use of a bent probe. In all probability the meatus had become widened.

I saw, in August 1859, a child about three years old, at Epping (a patient of Mr. Duncan Macnab, of that town), into whose ear a small oblong pebble had been introduced, just of sufficient size to occupy the auditory passage. There was no difficulty in touching and even moving the stone, but in every attempt to seize it with a pair of forceps the ends of the blades slipped off and jerked the body further towards the tympanum; and the introduction of a bent probe, or thin piece of metal, was impossible, owing to the narrowness of the passage. Mr. Macnab determined, in the absence of urgent symptoms, to wait and see what course nature would pursue. The following day, amidst a considerable quantity of thick puriform discharge, the pebble presented itself at the external orifice, whence it was easily and without pain extracted by a bent probe, and the little patient had no bad symptoms.

We should remember that the auditory passage is widest at the external orifice; then it narrows somewhat, and becomes wider again towards the membrana tympani. Thus foreign bodies, particularly when round or oval, can with difficulty be handled when they have passed through the contracted part of the tube. Singular stories are told of the effects produced by their long residence in the ear. Hildanus affirms that he cured a young girl of epilepsy by accidentally removing from the ear a foreign body which had been introduced seven years before, and had been quite forgotten! Small forceps and scoops are made to assist the surgeon. One of the most useful instruments is a long flat steel probe, the end of which can be made to bend to a right angle by a screw fixed at the handle. (Vide SURGICAL APPARATUS.)

Directions are given that such instruments should be introduced along the upper rather than the under wall of the meatus auditorius; that when the handle is raised so as to bring the end of the instrument over the foreign body, the point may recede from the membrana tympani, which is oblique in its direction from above downwards and inwards. It is unnecessary to condemn the unscientific suggestion of Duverney, namely, to make an incision behind the ear for the purpose of gaining space, for it must obviously be on the outside of the extraneous substance. Moreover, the cartilaginous external ear is a part on which the performance of a surgical operation is productive of the most severe pain. I remember the removal of a large part of the external ear, by Sir W. Lawrence, at St. Bartholomew's Hospital, from a man, the subject of chimney-sweep's cancer; and the patient, though rendered unconscious by the administration of chloroform, struggled so convulsively and uttered such loud cries as to attract the observation of those present. The great danger arising from the presence of a foreign body in the ear, is, that it should excite ulceration of the membrana tympani, and, falling into the middle ear, produce by its presence inflammation of the temporal bone. The compact structure of the petrous portion of the bone is ill able to withstand morbid processes; it soon dies, and sets up inflammation in the neighbouring substance of the brain. The patient, after undergoing agonising suffering, dies, labouring under cerebral symptoms; and upon examination after death an abscess is found, not uncommonly in the cerebellum, containing a greenish-coloured matter, occasionally fœtid, and surrounded by ragged and discoloured brain-substance. For such an occurrence we have but limited means of treatment. We read of cases in which paralysis of the arm or leg suddenly supervenes, of the occurrence of delirium or coma; and pathological investigation shows that the sinuses, namely, the longitudinal, lateral, and petrosal, may be full of pus and lymph, proving that the patient has been attacked by intracranial phlebitis, as well as by disease of the brain itself. (Vide DISEASES OF THE EAR.)

Foreign bodies introduced into the nose cannot excite the same dangers as in the former situation. They may in general be readily removed, either with the polypus-forceps or the scoop; the only danger attending the operation is that of breaking the spongy bones, or of pushing the substance backwards into the pharynx. Let it be remembered that, in children especially, there is no cause for anxiety or haste; the extraneous body will work its own way out, the surrounding parts receding so as to widen the passage by which it entered.

I was once consulted by a patient suffering from discharge from the nose, and found that the end of a style introduced some years ago down the lachrymal canal, but covered by the integuments of the face, projected into the inferior meatus. The removal of the instrument relieved the patient. A young man consulted Sir W. Lawrence in consequence of his suffering from discharge from the left nostril, accompanied with enlargement of the corresponding superior maxillary bone, which was soft and yielding. A probe introduced into the socket of the second molar tooth passed readily into the antrum, and allowed the escape of some thin sero-purulent fluid. In the course of a few weeks a small bit of lint escaped from the antrum through the socket of the tooth, the discharge from the nose ceased, the cheek regained its normal size, and the man recovered. It turned out that the lint had been used, steeped in laudanum, for plugging the socket and relieving a temporary attack of face-ache.

The presence of a foreign body in the nostril may become the cause of ozæna, and lead to the secretion of a fœtid puriform discharge; and attention has lately been directed to this subject by some of the surgeons of St. George's Hospital, who have pointed out the propriety in doubtful cases of careful examination, under chloroform, of the affected part.

In September 1859, two little boys, between six and seven years of age, came under the care of Mr. Prescott Hewett. The first was said to have passed a plum-stone up the nose, and the event was supposed to have taken place a year previously. On examination, some foreign substance could be recognised, with the probe, high up in the nostril, and wedged against the spongy bones. It was impossible to deal with it until chloroform had been given, and this having been done, a long screw (more than an inch in length) was with some difficulty extracted. The child soon recovered. The other had been under the care of various practitioners for the last three years, on account of 'discharge from the nose, ozæna,' &c., but without any suspicion entertained of a foreign body being present. On examination, Mr. Hewett recognised, at the top of the nostril, a black coloured substance, which seemed hardly like a portion of the natural tissues. The child was therefore put under the influence of chloroform, and a small black button (such as is used on boots) was extracted. The ozæna and discharge from the nose soon disappeared.* Another case has been described, in which a piece of wood-shaving was removed under similar circumstances.

For the treatment of the scars resulting from burns and scalds of the face, vide Plastic Surgery. I may here remark, that, after the application of heat in any form to the integument, the great point to ascertain is, whether the entire thickness of the skin has been destroyed. If only the superficial layer has been disorganised, repair goes on, without subsequent contraction, by means of a number of small florid and well-formed granulations. If, however, the whole thickness of the integument is involved, then to a certainty contraction will follow. The eyelid will be drawn downwards, producing ectropium; the nares may be narrowed and twisted; the mouth drawn downwards and to one side, exposing the teeth and jaw. The features cease to be in harmony, and the teeth become horizontal. Surgical skill is often in vain invoked to arrest the contraction; it goes on steadily and slowly, however we may arrange the plasters and dressings, or in whatever position the patient may be placed. It is in general after a lapse of years that relief from the deformity is sought; and then the disappointment attending plastic operations, or partial divisions of the contracted bands, has been too generally experienced to need comment. I would call especial attention to the treatment of these contractions by slow, gradual extension, the advantages of which proceeding merit more general attention: the contractile material of the cicatrix becomes slowly absorbed, and when once absorbed is not reproduced; the hard and puckered skin becomes soft and yielding, though never like healthy integument; and results are ultimately attained which surpass expectation. The objection to this practice, that it is slow and involves a treatment of many months, is not tenable, for the treatment of wounds made in the performance of plastic operations on cicatrices is very frequently more tedious still; and then it must be remembered, that after the wound has healed, a process of contraction goes on again in every part allied in its nature to a cicatrix, and in many cases the surgical operation has to be repeated.

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* *Brit. Med. Journal,* Sept. 24, 1859.

Cases occasionally present themselves in which the cheek becomes adherent to the gums, in consequence of sloughing of the lining membrane, and subsequent granulation and union of the adjacent surfaces. The movements of the mouth are always so much impaired that the power of mastication is lessened; and it occasionally happens that the teeth are so firmly clenched, that there is difficulty in giving to the patient the necessary nutriment.

I saw, in 1845, a lady to whom this accident had occurred, after profuse salivation, directed for the purpose of relieving her from an attack of psoriasis. The soreness of the mouth caused by the mercury was aggravated by the presence of some carious teeth, which the surgeon refused to remove. A very strong band of adhesion formed, which was twice divided by another surgeon; the relief thus afforded was temporary, and the closure of the mouth recurred in the course of a few weeks. About the same time I saw a boy, all of whose teeth were sound; but in whom sloughing of the mucous membrane of the cheek had taken place during the course of some eruptive disorder. Two cases very similar to the last have been lately treated in St. Bartholomew's Hospital. In the first patient, a young girl of fifteen years, a single band of considerable thickness had formed on the right side of the mouth. It was extirpated by operation down to the healthy structures; but, as cicatrisation proceeded, the mouth would have closed again, had not small ivory wedges been introduced between the teeth, and retained there by night as well as by day. In the second, a boy aged ten, the adhesions were more general: no operation was performed; and a limited amount of benefit was obtained by the employment of the ivory wedges. There was a case of contraction of the mouth in a man, a patient at the Royal Orthopædic Hospital (in 1859), who had been a sufferer from rheumatic disease of the articulation of the lower jaw. The tissues round the articulation were hard and unyielding, and scarcely permitted the least separation of the teeth. Considerable relief was obtained by slow extension.

In all these cases, whatever may be the primary cause, the rule to observe is, to avoid as much as possible the use of the knife. Division of the morbid parts must be followed, however skilfully the operation is performed, by the formation of a fresh cicatrix, in which the tendency to contraction will exist to the same extent as in the original cicatrix. Indeed, the mouth becomes stiff during the night while the patient sleeps, unless the jaws be kept artificially open. The treatment by the introduction of wedges of gradually increasing size is founded on this recognised principle, that pressure, however gentle, will, if steadily and unremittingly persevered in, gradually overcome the most powerful resistance; and experience shows us that, under such a process, the strongest bands of adhesions become elongated, absorption removing that part of their tissue in which resides the tendency to recontract. Consequently, when the mouth has once been opened by such a plan of proceeding, it is found on examination that the newly-formed tissue has lost its hardness, and that the advantages which the patient has derived are permanent.

Hæmorrhage from the ears, after injury, is commonly regarded as an indication of fractured skull; and such indeed it is, provided the flow of blood be copious. But there are other cases in which the hæmorrhage is not considerable, and seems to proceed from the lining membrane of the external ear, without the more serious complication.

A boy was admitted into St. Bartholomew's Hospital, December 14, 1843, having fallen on his head from a pillar six feet in height. His parents noticed that he was taken up insensible, blood flowing from both mouth and ears. His shirt was stained with blood. At the time of his admission he was just able to speak and answer questions. The head was shaved, and a cold lotion was applied; no bad symptoms supervened, and he was discharged well within a month.

Such cases are by no means uncommon in hospital practice, and may, with a little care, be readily distinguished from those of more serious character, in which the flow of blood depends on fractured base of the skull, and laceration of some of the venous sinuses. (Vide INJURIES OF THE HEAD.)

FRACTURES.

Fractures of the ossa nasi are not uncommon, and are usually attended with depression, but swelling and ecchymosis often render the diagnosis at the time of the accident difficult. In the Museum of St. Bartholomew's Hospital, there is a preparation showing the 'union of a transverse fracture of the ossa nasi a short distance above their lower border.'* When replacement of the depressed portions is practicable, the surgeon must introduce into the nostril some such instrument as a female catheter, or a pair of dressing-forceps, and apply pressure in the right direction. He is recommended to plug the nostril, when the tendency to displacement remains; but I do not approve, as a rule, of distending the nostril with a foreign body. It was remarked by Sir C. Bell, that no tubes can be employed so as to support the broken bones; and when these have been replaced, they will not readily change their position, as they are acted on by no muscles. Hæmorrhage may be profuse for a time, but usually ceases spontaneously, or upon the application of cold. Plugging the nostril should not be resorted to except in cases of severe displacement of the bone, for it causes the patient great discomfort, and not uncommonly fails to effect the purpose for which it is used. Cases occur in which the septum nasi, together with the crista galli and cribriform plate of the ethmoid bone, are driven upwards to the skull; and there may be injury to the brain and escape of cerebral matter. The fracture of the facial bones is here comparatively unimportant; and the injury must be regarded as a variety of fracture of the base of the skull, of which the rules of treatment are given in the essay on INJURIES OF THE HEAD. In the same way, injuries of the lachrymal bone involving the nasal duct, will be considered under the head of INJURIES OF THE EYE. The eye may be bruised by the same injury which has broken the nasal bones, but it is rarely affected secondarily by inflammatory disturbance.

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* Ser. iii. prep. 75.

Mr. South relates the case of a man who was struck on the face with the handle of a crane, and in whom all the bones were separated and loosened, 'feeling like beans in a bag.' The bones may be crushed by the passage of a bullet, or by a fall on the face from a great height. The chances of recovery depend upon the amount of injury which has been sustained by the brain. We have no means of setting or adjusting the broken bones, and we must be content with general treatment. The teeth are commonly loosened, or completely detached. In the former case it should be remembered that they may again become firm, and should be left *in situ.* A completely detached tooth replaced in the socket may, it is true, contract some adhesion to the gum; but sooner or later it acts as a foreign body, and, after exciting irritation, falls out, to the great comfort of the patient.

Hyrtl remarks, that an observation by Pétrequin and Bouchacourt on injuries in this region is of importance in a medico-legal point of view; namely, that wounds of the face caused by the violent action of blunt instruments have often the same appearance as if inflicted by the sharp cutting edge of a knife. The sharp border of the superior maxillary and malar bones, or the edges of the teeth, will, when a blunt body presses against them, cut through the skin and subjacent soft parts, and cause an injury closely resembling an ordinary incised wound.

Middeldorpf[*] relates a case of fracture of the upper jaw and malar bone, together with fracture of the vomer and ethmoid, accompanying fracture of the lower jaw, from a fall. He points out the possibility of a fracture of the upper jaw in consequence of a blow upon the chin. The symptoms, resembling those of fracture of the base of the skull, which sometimes accompany fracture of the malar bone, have been already referred to under INJURIES OF THE HEAD, p. 283; and some further observations on the treatment will be found at p. 433.

Fractures of the lower jaw.—The lower jaw is the strongest of the bones of the face; the lower margin of its body is more prominent than the upper, which is composed of alveoli, and contains the teeth: the front surface is therefore oblique, from below upwards and backwards; and this obliquity becomes the more marked as the teeth drop out and the alveoli become absorbed in the processes common to old age. Indeed, in the jaw of a very old person, the mental foramen approaches the upper border of the bone. The rami are nearly perpendicular to the body in middle age, but in both very old and very young the direction is obliquely backwards, and approaches the horizontal. The strongest part is the symphysis, or that part where the two halves of the bone, separate in fœtal life, become coalesced in the course of development. In this immediate spot fracture rarely occurs, the bone usually giving way a short distance either to the right or the left, where it is thinner, in the space between the symphysis and the insertion of the masseter. In other cases, the fracture occurs at the angle, or in the ramus of the jaw, the coronoid process, or the condyle. The bone may be broken in more than one place; fracture may be combined with dislocation.

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[*] *Beiträge zur Lehre von den Knochenbrüchen,* von Dr. A. Th. Middeldorpf, Breslau, 1853.

Bonn[*] gives an account of fracture combined with dislocation of the condyle of the lower jaw. There was a longitudinal fracture in the middle of the bone, and at the same time the right condyle was broken off from the neck, and dislocated forwards and inwards, where it lay united by callus, near to the foramen ovale (foramen maxillare posterius). The pointed upper extremity of the neck of the lower jaw articulated with the glenoid cavity, and the separated 'head' with the lateral part of the tubercle of the temporal bone. There was motion in the joint. The same author mentions a case of fracture and dislocation of both condyles of the lower jaw. In a young man, who had had numerous other fractures, and who died five weeks after the accident, there was found, besides a longitudinal fracture of the middle of the bone, fracture and complete separation of both condyles, which were drawn forwards and inwards as in the preceding case, and fixed by callus, not far from the foramen ovale, on either side. On the left side, the articular or glenoid cavity was externally rough and uneven, and surrounded by a rough callous border; on the right side it was divided into two parts, of which the inner was hollowed out and smooth; the other uneven, and surrounded by a prominent callous ridge. The smooth cartilage-covered condyles were in contact with the cartilage-covered tubercle; the pointed upper extremity of the neck of the lower jaw, with the uneven surface of the glenoid cavity.

During the course of the year 1860, Mr. Holmes exhibited at the Pathological Society of London a specimen of a fractured portion of the neck of the lower jaw driven into the meatus auditorius externus. The accident was followed by serous discharge from the ear, simulating one of the symptoms of fracture of the petrous portion of the temporal bone at the base of the skull. The diagnosis of such cases is treated of under the head FRACTURES OF THE BASE OF THE SKULL. J. L. Petit mentions a case in which the bone was broken and the coronoid process completely denuded by a kick from a horse. Surgical writers have affirmed that serious cerebral and nervous symptoms may accompany fractures of the lower jaw; the former due to the amount of general violence which accompanied the local injury, the latter to laceration of the dental nerve in its course through the canal in the bone. The cerebral symptoms here referred to would be accidental, such as might accompany an injury to any other part of the body. The nerve-symptoms mentioned have not hitherto been witnessed by me in any such case; and Middeldorpf,[†] who has written on the subject, affirms, that 'laceration of the *nervus alveolaris* never excites dangerous complications.' He records nine cases, and remarks that the displacement of the bony fragments is very often due to the direction of the force rather than to muscular action. It is unnecessary to remark upon the proposal of Fattori, to trepan the front wall of the jaw in cases of neuralgia, and to cut out or otherwise destroy the nerve.

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[*] A. Bonn, *Descriptio thesauri ossium morbosorum Hoviani*, Amstelædami, 1783–4; and ejusdem *Tabulæ ossium morbosorum præcipue thesauri Hoviani*. Ibid. 1785–8; or Gurlt, *Beiträge zur pathol. Anat. der Gelenkkrankheiten*, p. 122. Berlin, 1853.

[†] *Beiträge zur Lehre von den Knochenbrüchen*, von Dr. A. Th. Middeldorpf, p. 52, Breslau, 1853.

Non-union, or even tardy union, of fractures of the lower jaw is very rare.

In the *London Medical Repository* for 1823, a case is noticed in which Dr. Physick cured such a case by means of a seton; and Ancelon relates the following case, in which the want of union appears to have been due to disease, perhaps partial necrosis, caused by the unnecessary amount of violence. A farrier presented himself with double fracture of the lower jaw, which had not been treated for five months. He had allowed a brother farrier of powerful frame to pull out a tooth for him, and in the act the whole middle piece (*i.e.* body) of the lower jaw was broken off a short distance in front of the masseters on either side. Upon examination five months after the accident, M. Ancelon found the middle piece movable and producing crepitus on the opposed surfaces; the gum was thick and infiltrated, and the smell from the mouth almost unbearable. In consequence of some misunderstanding, nothing was then done, although the surgeon felt inclined to remove the whole bone. A year and a day afterwards the man returned, wishing to get rid of his present suffering at any price. The left ramus of the jaw had been entirely separated and lost: the cicatrices by which it had come away being quite visible: a firm band was felt under the skin, passing down in the same situation to the middle piece of the jaw. The middle piece still contained one canine, two bicuspidate, and one molar, teeth. The right ramus remained in the socket, but the broken end was pulled up and pushed into the soft parts. The whole cheek was swollen; the angle of the jaw was carious and protruded through the skin. M. Ancelon removed the entire right ramus. The middle piece remained attached to the fibrous cord on the left side, and the patient regained sufficient power to masticate light food.*

When fracture occurs about the middle part or body of the lower jaw, the signs are sufficiently obvious. There is mobility of the parts, crepitus, and irregularity in the line of the teeth; the gums are torn and bleeding, the mouth is usually partly open, and the saliva dribbles away. It is commonly affirmed that, when the middle portion is broken on both sides of the symphysis, the detached fragment is drawn down by the depressor muscles of the lower jaw: such is sometimes the case, but the direction of the force applied must also be taken into consideration, as well as the inclination of the fractured surfaces. When fracture occurs in the ramus, or about the neck or coronoid process of the bone, the displacement is either inconsiderable, or else in such a situation as to be recognised with difficulty. The surgeon must then trust to careful examination and inquiry into the character of the accident, remembering that the presence of deep-seated fixed pain, on examination, in a bone, after a severe injury, is a good diagnostic mark of fracture. There are some who speak of 'compound' fracture of the jaw, where the gum is lacerated or the integument torn. The term, perhaps, is scarcely applicable in the sense in which it is used in cases of fracture of the long bones. In the latter the gravity of the complication consists in the laceration of the mass of soft parts, muscles as well as integument, covering a dense hard bone, such as the femur or humerus. Inflammation and suppuration are apt to ensue, producing exhausting discharges and hectic fever. In the former case, the laceration of the gum, or of the integument covering the jaw, is a matter of comparatively little moment; it adds nothing to the severity of the case: the soft parts unite readily enough, being a thin and highly-organised layer. The bone, also, more highly organised than the long bones, throws out, without effort, the proper material for repair. Beyond, therefore, the pain which such an accident causes, there is little ground for anxiety in ordinary cases, either to the surgeon or to the patient.

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* Double Fracture de la Machoire inférieure, *Gaz. des Hôpit.*, 1854, p. 550.

The treatment consists in maintaining the parts in steady apposition for from four to six weeks. During this period the patient must not attempt to chew solid food; he must live on soups, sopped bread, and other similar substances, which can be easily swallowed. He will not feel disposed to talk much, and, in so doing, should avoid moving the jaw. As a rule, he will content himself with merely expressing his wants. If the fracture be not attended with much violence to surrounding parts, there is no necessity to prescribe absolute rest; but, in cases where the soft structures are much lacerated and bruised, bed is the fittest place until swelling has entirely subsided.

Various substances are employed for the manufacture of a splint. That in most common use is gutta-percha, which, when properly heated, adapts itself accurately to the injured parts. The exact size and shape having been previously ascertained and determined, the gutta-percha should be cut accordingly, and then immersed in water heated to just below boiling-point. In the course of a very few minutes it becomes soft and perfectly pliant. It should then be removed from the water, and pressed for a moment between the folds of a dry towel. In this state, moderately dry and deprived of superfluous heat, it is to be put on the surface intended for support, and bound thereto by a roller. In the case of the jaw, the 'four-tailed' bandage is of use in attaching the parts firmly to the head. The common causes of failure in the making of gutta-percha splints arise from the following circumstances. First, the water is not hot enough; secondly, the accessory appliances are not quite ready at hand; and thirdly, the surgeon is not quick enough. The whole proceeding should occupy a very brief space. Unless the gutta-percha is properly heated, it does not adapt itself, and the support which it affords is imperfect. A preparation of vulcanised india-rubber, now much used by dentists for the construction of artificial palates, &c., is also applicable for the purpose now before us. Cardboard, leather, or even the four-tailed calico bandage stiffened with starch, may be employed when other materials cannot be obtained.

When the injury has been considerable, as in the case of a gunshot wound, it may happen that no apparatus can be applied; union will go on equally well under a soft bread-and-water poultice, often renewed. The condition of the parts is such as to guarantee from the patient himself most perfect rest. The practice of tying the teeth together was known to Hippocrates. Cases occur in which it may be employed with some advantage; and then the surgeon should use the metallic in preference to the silken ligature, inasmuch as the latter is more apt to cut through the enamel of the teeth and to induce caries. When the teeth in the upper jaw are perfect, and can be applied to a set similarly perfect in the lower jaw, they serve as a useful splint, exerting counter-pressure to that caused by the gutta-percha.

The process of repair is not by provisional callus. A connecting material is poured forth from the vessels of the bone, in which ossification goes on in the usual way; the torn gum heals; teeth which have been only loosened regain their normal firmness; and the repair is usually perfect.

In cases of fracture about the ramus, condyle, or coronoid process, no more can be done than to keep the jaw quiet by means of the four-tailed bandage, either with or without any other splint, for the usually prescribed period. In the first situation, the masseter and internal pterygoid muscles prevent much displacement; in the second and third, the injured parts are beyond our reach. The detached condyle will be pulled forwards and inwards by the external pterygoid muscles, towards the base of the skull, near the foramen ovale, as described in the cases already recorded. The coronoid process may suffer some displacement by the action of the temporal muscle, but this may be inconsiderable, in consequence of the great extent of the insertion of the muscle, which reaches near to the last molar tooth. In all these cases an examination by the mouth may assist in our diagnosis.

Mr. James Salter, of Guy's Hospital, has adopted a useful mode of treatment in cases of fracture of the upper jaw. He prepares a gold plate to fit the interior of the mouth, so as to hold the displaced portions of bone as much as possible in position, thus far acting in every sense as a splint; but with the additional advantage that it is capable of repeated alterations from time to time, so as to force outwards inwardly projecting bone and teeth, as the patient can bear the pressure. He first takes an accurate model of the mouth, and upon this the plate or splint, whichever it may be called, is constructed, embracing some of the firm teeth. The plate is so framed as to exercise pressure only on the bone and teeth which are displaced.

The beneficial effect of this plan was proved in an interesting case recorded in the *Lancet* (June 16, 1860). A young gentleman, while playing at cricket, rushed forward with great impetuosity to catch the ball, when one of his companions, not perceiving him, and running forwards with a similar object, came into collision with him, and struck him a violent blow with his forehead on the upper jaw, immediately below the malar bone. There ensued a fracture of the maxilla, driving inwards the two right upper premolar teeth and the first molar, with their alveoli. The patient, by means of pressure gently maintained by the above-described splint, recovered completely in about six weeks; the displaced bone and teeth resuming their normal position.

Mr. Salter believes that the same principle may be adopted in fractures of the lower jaw. Any displacement that accompanies fracture of the superior maxilla is simply a passive condition; there are no muscles attached to the upper jaw which can derange or draw out of place the broken bone. With the lower jaw, however, the case is very different; the inferior maxilla is a floating bone, to which many powerful muscles are attached, and those connected with the rotating movement of the jaw—namely, the pterygoids—have a strong lateral antagonistic action. Destroy the integrity of the maxillary arch by fracture, and that antagonism ceases; the muscles on either side act independently, and draw the points to which they are attached more or less to the mesial line, and this it is which causes the overlapping of the fractured ends of the bone, often so obstinate. A plate or splint (for the lower jaw, Mr. Salter prefers an ivory one), carved to fit the interior of the arch of the particular jaw, with small crescentic excavations for the existing teeth, when placed in the mouth, restores the integrity of the arch for the time being. It may be worn without inconvenience long enough to allow osseous union of the fractured ends, preventing displacement the while.

It is asserted that in rabid horses fracture of the jaw occurs from muscular cramp alone.

The separation of splinters of bone, the treatment of abscesses, of necrosis, and other accidents common to fractures in general, must be conducted on the general principles of surgery.

Dislocations of the jaw.—The articulation of the lower jaw is the only one in the face which allows the head of the bone to escape from the articular cavity; the molar teeth of the upper and lower jaws are separated in mastication by the sliding forward of the condyles of the latter upon the eminentiæ articulares, while the adaptation of the bony surfaces is completed by the interarticular cartilage and its synovial membranes. The lower jaw slides forward upon the eminentiæ articulares in the act of masticating, of yawning, of laughing; and it is in one of these conditions in general that dislocation of the condyles under the zygomatic arch ensues, by the combined action of the masseters and internal pterygoid muscles. The temporal muscle drags the dislocated bone upwards.

The only direction in which this dislocation can happen is forwards. That in the backward direction is impossible, unless the osseous structure of the external ear is broken at the same time. Behind the condyle of the jaw lies a portion of the parotid gland and the mastoid process of the temporal bone. But displacement of either one or both condyles forward is of occasional occurrence. When recent, these accidents are attended with much pain. The mouth is open, and cannot be shut: an empty space is left before the ear in the natural situation of the condyles. The coronoid process may be felt through the cheek, or within the mouth, and there may be some flattening of the cheeks and temples. The saliva flows in great quantity.

The relation of the teeth is altered. When only one condyle is dislocated, the incisor teeth incline to the right or left side; and this fact can be readily ascertained by careful examination. After a time these symptoms, if the dislocation be not reduced, are not so well marked; the patient gradually regains the power of articulation and of swallowing, and can retain the saliva; but the sense of great discomfort remains for a long time.

Hippocrates declared the accident mortal, if not reduced before the tenth day; but this is clearly an error. I have seen a patient four months after the accident, with dislocation of both condyles into the zygomatic fossæ. The patient had suffered and was still bearing much pain, but the symptoms were becoming more endurable and the deformity was less apparent: an attempt to reduce the dislocation failed. In endeavouring to reduce a dislocation of the jaw, the surgeon cannot do better than follow the old rule, when the accident is recent: 'Let him wrap some linen round his thumbs, to keep them from being hurt by the patient's teeth, and then introduce them into the mouth, as far as possible along the grinding teeth; at the same time he is to place his fingers under the chin and the base of the jaw, and while he depresses the molars with his thumbs, he raises the chin with his fingers, by which means the condyles become disengaged from their situation under the zygoma; at which instant the muscles draw those parts so rapidly back into the articular cavities again, that the surgeon's thumbs might sometimes be hurt, did he not immediately move them outward between the cheek and the jaw.'*

In the present day we use chloroform in difficult cases, and have recourse to what Mr. Samuel Cooper calls the practice 'of the ancients,' namely, the insertion of two pieces of stick between the molar teeth, to be used as levers to depress the angles of the jaw, while the chin is raised by the hand or by a bandage. But even with this plan, usually successful, I have witnessed failures, and have myself failed to move the jaw in a case of old luxation, where the parts had adapted themselves to their new position. All dislocations of the jaw, from accident, should be reduced without delay.

HOLMES COOTE.

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* *Cooper's Surgical Dictionary*, ed. 1830, p. 390.

INJURIES OF THE NECK.

Wounds

WOUNDS of the neck differ greatly in character, extent, and danger. The parts involved vary with the situation, direction, and depth of the wound, and also in some degree with the position of the head and neck at the time the injury is inflicted.

Accidental wounds of the neck are rare. They are more frequently punctured than incised, and are often somewhat contused. They result for the most part from falls upon sharp instruments or projecting points, and, as a rule, take a direction from below upwards and backwards.

Homicidal wounds of the neck are not uncommon.* They are generally incised, and often designedly simulate self-inflicted wounds. They seldom present any distinctive appearances. The stabs of the assassin in this region are usually directed from above downwards and towards the middle line.

Suicidal wounds of the neck are comparatively common.† They are more common in this country than on the Continent.‡ These wounds are almost always incised, and are often lacerated with more or less jagged edges. They are ordinarily made from left to right, and obliquely downwards or transversely across the throat. They seldom sink so deeply into the side of the neck as to reach the great vessels. The larger extent of the wound is, in most instances, on the left of the middle line; but this is not invariably the case, even though the right hand have been used.* Dieffenbach records the case of a young man who, having taken a razor in each hand, at the same moment cut across his neck from left to right, and from right to left. The wounds crossed one another over the larynx and trachea.† Most frequently the suicide makes but one gash. Sometimes, however, several wounds are inflicted before the fatal or final one is made. It is important to bear in mind that in consequence of its elasticity and mobility, the skin of the neck is easily thrown into folds and irregularly stretched; and thus several distinct cuts may be produced by a single stroke of the knife. The jagged and uneven appearances often presented by continuous wounds may be explained, to a certain extent, in the same manner.‡

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* During the five years 1863–7, out of 612 murders and infanticides perpetrated in England by specified methods, 56 were accomplished by wounds of the neck. During the same period, out of a total number of 6,696 suicides, 1,235 were cases of cut throat. See *Report of Registrar-General.*

† See previous note.

‡ The statistics of Brierre de Boismont (*Du Suicide*; Paris, 1856) show out of 4,595 cases of suicide only 121 by cut throat.

Punctured wounds are occasionally, though rarely, made in this region with suicidal intent. Lord Castlereagh, as is well known, destroyed himself by thrusting a penknife through his carotid artery. His method was attempted shortly afterwards by many would-be suicides, but in most instances without fatal result. Laugier § quotes the case of a lunatic, who, having penetrated his larynx by the point of a penknife, divided his thyroid cartilage into eight parts by turning the knife in various directions.

Suicidal wounds of the throat are most common among men of intemperate habits and broken health, who have passed the middle period of life. Sometimes they are inflicted during delirium; sometimes in fits of extreme despondency; sometimes, but not often, under the influence of privation or pain, or of distress of mind, delusion, or fear. Under any such circumstance the condition of the sufferer is unfavourable alike to recovery from the shock of the injury, and to subsequent repair of the damage sustained. Hence, these wounds are more likely to prove fatal than accidental or homicidal wounds of similar extent and severity. Hence also, special care and watchfulness are necessary in their treatment.

Wounds of the neck may be divided, for convenience of description, into those inflicted behind, those in the lateral regions, and those in front. Very often, however, the wound extends from one region to another.

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* In *St. George's Hospital Reports,* 1866 (p. 368), reference is made to a recent example.

† Dieffenbach, *Sur les Plaies du Cou. Archives générales,* 2e série, t. vi. p. 237.

‡ For the medico-legal bearing of this point, see Casper; Sydenham Society's translation, vol. i. p. 129.

§ *Dictionnaire enc.* (30 vol.), t. ix. p. 168.

1. *Wounds of the back of the neck* are less likely to prove dangerous to life than those in front. But it has been stated that they 'often produce a palsied condition, and frequently a wasting of the lower limbs.' 'Wasting of the testicle and loss of the generative power' are also said to have been observed.* It is difficult to obtain good evidence in support of these statements, and it is probable that they apply only to cases in which the spinal canal has been penetrated.

M. Legouest saw in Algeria many cases in which very deep transverse wounds in the back of the neck had been made by the Arabs in their attempts to decapitate the soldiers who had fallen into their hands.† 'The results were satisfactory, in spite of the size and thickness of the cicatrices;' and no such effects as those above alluded to appear to have been produced.

A deep wound in the upper part of this region, especially if made when the head is bent forwards, may penetrate between the occiput and atlas, or between the atlas and axis, and implicate the spinal cord or its membranes. There is no other part in which the cord can be so easily reached by a pointed or cutting instrument; nor is there any in which a wound of the cord is so likely to prove speedily fatal.

When the cord is wounded, sensation and the power of voluntary motion are instantly lost to an extent corresponding to the injury inflicted. A flow of cerebro-spinal fluid from the wound also occurs. This is often considerable, and sometimes continues for several days. Cases have happened in which the spinal membranes have been cut, but the cord has escaped almost intact. In such cases, an escape of cerebro-spinal fluid has been observed.

M. Laugier ‡ refers to instances of infanticide accomplished by means of a long needle passed between the atlas and axis into the cord.

Wounds of the cord or its membranes in this region are extremely dangerous from their immediate effects, or from subsequent inflammation. But death is not invariably the result. Cases are on record in which life has been preserved, but in which there has been permanent paralysis of various parts.[*] Morgagni relates the instance of a young man who was stabbed in the neck, three fingers' breadth below the ear. He fell, deprived of sensation and motion in all parts of the body below the head; but at the end of four months he recovered the power of walking.[†]

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* Chelius, *System of Surgery*, translated by South, vol. i. p. 437.

† L. Legouest, *Traité de Chirurgie d'Armée*, Paris, 1863, p. 407.

‡ Op. cit.

A deep punctured wound behind and below the ear may implicate the vertebral artery. A case of this kind is recorded in which a false aneurism was formed: this led to the death of the patient some months after the injury.[‡]

In the treatment of deep wounds of the back of the neck, especially if the muscles have been extensively divided, attention to position is of very great importance. The patient should lie upon one side, with his head in the same longitudinal plane as his body, but inclined somewhat backwards. The head should be supported and firmly fixed by means of sand-bags, or bandages, or some special apparatus; otherwise its natural tendency to fall forwards may cause separation of the lips of the wound, or even give rise to some degree of tension, or pressure upon the spinal cord. Sutures and adhesive plaister may be used, according to circumstances, to aid the closure of the wound; but in most cases 'position' affords the best means of alleviating the pain and promoting favourable cicatrisation.

2. *Wounds in the lateral regions of the neck* are almost always either accidental or homicidal in origin. For the most part they are inflicted by the assassin's dagger, which too often is plunged with fatal effect into the root of the neck. Such wounds are very dangerous from their liability to implicate the great vessels and important nerves. Sometimes the upper part of the cavity of the chest is penetrated, and the lung wounded. Occasionally, the blood-vessels and nerves and other important structures escape in an almost marvellous manner; and recovery may take place, even though the lung has been wounded.

A case of this kind has recently been under the care of Mr. Birkett, in Guy's Hospital. A stab from above the clavicle implicated the lung; there was emphysema, but little or no bleeding. The patient made a good recovery.[§]

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[*] Longet, *Anat. du Système nerveux,* vol. i. *Dictionnaire encyclopédique des Sciences médicales,* t. vii. p. 70.

[†] Quoted in *Dictionnaire enc.* (30 vol.), art. *Cou.*

[‡] *Archives générales,* 2e série, t. v. p. 138.

[§] *Lancet,* September 4, 1869, p. 337. See also a remarkable case recorded by Gross, *System of Surgery,* vol. ii. p. 385. A young man was stabbed in the

3. *Wounds of the front of the neck* may be made anywhere between the upper border of the sternum and the lower jaw. Sometimes they are mere abrasions of the skin. Sometimes they are superficial, implicating the subcutaneous structures as well as the skin. Sometimes they are deep, penetrating the air or food passages, or both, or even extending through all the soft parts down to the spinal column.

Superficial wounds in this region are not altogether free from danger. They are often attended by considerable hæmorrhage. If the external jugular vein is wounded, death may ensue, either from loss of blood, or from entrance of air into the vein.*

In some cases diffused cellulitis occurs, and spreads rapidly. Sloughing may ensue, or pus may burrow in various directions, sometimes even extending into the anterior mediastinum. Wounds over the thyroid cartilage occasionally give rise to inflammatory œdema of the larynx and pharynx; and there may be difficulty of breathing, alteration of voice, and pain in swallowing, although the mucous membranes have not been injured.

In consequence of the elasticity of the skin, the laxity of the areolar tissue, and the action of the platysma myoides muscle, the edges of these wounds are often widely separated at first, and have a great tendency to roll inwards when attempts are made to bring them together. Hence arises, in part, the difficulty often met with in obtaining primary union. This difficulty is increased by the frequent movements to which the neck is liable. Accurate coaptation of the lips of the wound is best secured by a very fine continuous suture, or by many short stitches near to one another; these should be passed through the skin only, and so close to the edges that no portion can roll inwards. The elasticity of the skin and the action of the platysma may be counteracted by long strips of adhesive plaister applied obliquely across the neck, or parallel to the fibres of the platysma. Tension upon the wound and the general movements of the neck may be, to a great extent, prevented by supporting and fixing the head in proper

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neck by a long narrow knife. The œsophagus, trachea, and great vessels escaped. But the right upper extremity became immediately palsied. General recovery took place, but the paralysis remained.

* A remarkable case of sudden death from wound of the external jugular vein is recorded in the *Boston Medical Magazine*, vol. iii. p. 117.

position. Whatever pains, however, may be bestowed, it often happens that primary union does not take place; and the process of healing by granulation is but slow.

Deep incised wounds, which penetrate into the air passages, very generally implicate other important parts also. Such wounds are liable to be attended by certain dangers and complications more or less common to all, whatever their precise situation; and by others which vary with the particular structures involved.

Some idea as to the relative frequency with which the different portions of the air tube are wounded, may be gathered from the following summary of 158 unselected cases, of which I have obtained particulars.

Situation of Wound.	Number of Cases.
Above the hyoid bone	11
Through the thyro-hyoid membrane	45
Through the thyroid cartilage	35
Through the crico-thyroid membrane, or cricoid cartilage	26
Into the trachea	41

The sources of danger, and after-complications common to most of these wounds, irrespective of their precise situation, are as follows:—

1. Hæmorrhage, arterial or venous, may prove fatal almost instantly, or very speedily and before assistance is at hand. Sometimes, after having completely ceased for a time, during syncope or from some other cause, it recurs to a serious extent. This is especially likely to happen when a small opening has been made into one or other of the great vessels. As a general rule, the great vessels escape in cases of suicidal cut throat. They owe their comparative immunity, in the first place, to their elasticity and mobility, and the consequent ease with which they are carried, as it were, with or before the knife; and in the second place, but not less notably, to their situation. When a gash is about to be made in the upper part of the neck, the head is thrown back, and the pharynx is brought well forward. The incision must be deep indeed to reach the carotids or jugulars. Again, when the incision is over the larynx, the cartilages oppose so much resistance that the power of the suicide is generally expended before the needful depth is attained. Lastly, when the incision is still lower, the sterno mastoids contract spasmodically on the stimulus of the knife, and defend the deeper structures. It is probable also, as pointed out by Mr. Hilton in his Anatomical Lectures, that

when the windpipe is opened below the glottis, air immediately escapes from the lungs; consequently, the chest-muscles which act upon the upper extremity lose to a certain extent their support, and the arm falls. Thus, the would-be suicide, if he have the desire, may be deprived of the ability to carry his attempt further.

2. Blood may be drawn, or may flow into the air passages faster than the sufferer can expel it; and asphyxia may quickly result. Or a clot of blood may get into the larynx, and destroy life.*

3. Air may enter a wounded vein, and cause sudden death, or give rise to alarming symptoms, which may either subside, or ultimately lead to a fatal result. This accident is most likely to occur if one of the large veins at the root of the neck has been opened, but not cut through. It may happen, however, in wounds of the smaller veins, and even though the seat of injury be comparatively high in the neck.†

Le Gros Clark mentions a recent case in which the incision was above the hyoid bone. Death resulted in about twenty-four hours. Dyspnœa came on gradually, and increased until life was extinct. 'At the autopsy, the blood in the heart was found churned up and frothy. . . . . Investigation at the seat of injury suggested that a half-divided vein, which had been ligatured only on its distal or bleeding side, had slowly absorbed air, the admixture of which with the blood had proved fatal.' ‡

4. The divided structures may be so displaced as to impede or absolutely obstruct respiration. For example, if the incision is above the hyoid bone, the tongue may be cut through, and its posterior portion falling back, may occlude the larynx, and produce suffocation. Such a case has lately come under my observation in Guy's Hospital.

If the incision is between the hyoid bone and the thyroid cartilage, the epiglottis may be divided, or separated from its connections, and may give rise to alarming symptoms.

In a case of cut throat recorded by Mr. Houston,§ the epiglottis, loosened from its upper and lateral attachments, was left hanging by its pedicle to the back of the pomum Adami, and having fallen over the rima glottidis, obstructed respiration so completely that, within a few minutes after the accident, symptoms of suffocation ensued. The epiglottis was raised, brought over the edge of the thyroid cartilage, and secured by a single stitch to its anterior surface. Respiration returned. The man in a short time sat up, and attempted to speak, but was unable to articulate.

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* See Hilton's *Clinical Lectures. Guy's Hospital Reports*, 3rd Series, vol. xiii. p. 31.

† See vol. i. p. 756 of this Work, on 'Entrance of Air into Veins.'

‡ *Lectures on the Principles of Surgical Diagnosis, delivered at the Royal Coll. of Surgeons*, p. 225; also *British Medical Journal*, August 21, 1869.

§ *Dublin Hospital Reports*, vol. v. p. 315, cited by Ryland.

If the laryngeal cartilages are cut through, a detached portion of one or other may get into the glottis.

A remarkable instance is mentioned by Sir C. Bell.* A man who had cut his throat suffered occasionally from great difficulty of breathing, accompanied by a flapping sound in the throat. After death it was found that one of the arytenoid cartilages had been divided and hung by a membrane. It vibrated in the chink of the glottis, 'like a pea in a cat-call' during life; and finally acting as a foreign body it caused suffocation.

If the trachea is cut through, the divided portions are liable to become very widely separated, and the soft parts may intervene and prevent the free entrance of air.

Casper † relates an instance in which it appeared evident that death resulted from some such cause. Richet ‡ in 1854 communicated to the Société de Chirurgie a very interesting case in which the œsophagus projected forwards and became interposed between the cut ends of the divided trachea.

5. Emphysema may occur in any case in which an opening has been made into the air passage below the glottis, and in which the expired air cannot find free exit. It may be especially looked for, if the wound through the integuments does not correspond in situation and proportionate extent with that made into the larynx or trachea. Such emphysema may spread rapidly through the subcutaneous areolar tissue of the head, neck, and thoracic parietes, and even as far as the scrotum; § or, taking the course of the trachea and œsophagus, it may reach the mediastina. Hilton states that emphysema about the phrenic nerves may so far interfere with their functional integrity as to lead to a fatal result. It is said that in wounds of the larynx, emphysema may extend through the submucous tissue, and, by constricting the glottis, rapidly produce suffocation. As a general rule, however, emphysema is not in itself a dangerous complication.

6. The voice may be modified, or entirely lost, either as an

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* *Surgical Observations,* vol. i. p. 44.

† *Handbook of Forensic Medicine,* New Sydenham Society's Translation, vol. ii. p. 18.

‡ Quoted in *Nouveau Dictionnaire de Médecine et de Chirurgie,* vol. ix. p. 640.

§ See cases recorded in *Plaies du Larynx, de la Trachée, etc.* pp. 53, 71. Par le Dr. Paul Horteloup. Paris, 1869.

immediate and direct effect of the injury, or subsequently, in consequence of inflammatory changes. The manner in which the voice is affected, and the persistence of the affection, vary with the parts especially involved. If the windpipe is opened below the vocal cords, air may escape through the wound, and aphonia may result. In such cases, however, the voice may be temporarily restored by closing the wound, or by approximating the divided structures by change of position.

7. Dysphagia, or even absolute inability to swallow, may immediately result, or may subsequently arise. Saliva, mucus, food, and drink, may escape through the wound; and much suffering may be occasioned. Such symptoms are most certain to occur if the food passage has been extensively opened; but they may arise even though the incision has not penetrated beyond the air passage. In consequence of inflammation, or of some nerve-lesion, it may happen that during deglutition the epiglottis does not become properly lowered; or the larynx is not carried far enough upwards and forwards. Consequently fluids, and even solids, may traverse the glottis, get into the trachea, and issue from the wound. Such an occurrence is by no means uncommon after tracheotomy, in cases of diphtheria.

8. Inflammation and œdema of the parts about the glottis may rapidly supervene and endanger life.

9. Abscesses and purulent effusions, originating in the immediate neighbourhood of the wound, may spread rapidly in various directions, through the loose laminated areolar tissue, and produce the gravest symptoms. Sometimes they run down to the root of the lung, or implicate the pleura, and fatal results ensue. Sometimes by pressure they impede respiration, or interfere with the venous circulation, and cause œdema.

10. Bronchitis and broncho-pneumonia are common and often dangerous after-complications. They may be caused by extension of inflammation from the wound, by admission of unwarmed, unmoistened air into the lungs, or by irritation set up by the entrance of blood, pus, or foreign bodies, or portions of food, drink, &c., into the air passages. In eight out of ten fatal cases of cut throat, recently treated in Guy's Hospital, in which the more immediate effects of the injury had been survived, death was due to these affections.

11. The natural passages may become constricted during cicatrisation, or may be obstructed by the growth of exuberant granulations round the wound. Such complications require

very careful management, for they are almost certain to increase in severity and importance with the lapse of time.

12. A fistulous opening into the air passage or the gullet may remain after the wound generally is healed. Such a complication is very rare, but numerous well-authenticated instances are on record.* It is most likely to occur in cases in which portions have been entirely cut away, or in which there has been very wide separation of parts, and healing has been very slow.

Dr. Gairdner † narrates the case of a man who cut his throat with a razor, dividing the larynx at the upper part of the cricoid cartilage, and the œsophagus also. The cut extremities receded from each other to the distance of at least three inches. Attempts were made to unite the divided larynx by means of sutures, and to pass a gum elastic catheter from the nostril into the œsophagus, but without success. Ultimately the man recovered, with an aperture in the front of the neck, through which respiration was performed, and through which liquid nourishment was conveyed into the stomach by means of an elastic tube, introduced at each meal into the lower portion of the œsophagus. Two years after the infliction of the wound, this patient was strong and fat, and had all the appearance of a person enjoying excellent health.

Some of the more special effects and complications, which vary with the situation of the wound, may now be discussed.

a. Deep wounds between the lower jaw and the hyoid bone, besides dividing all the superficial structures, and the depressor muscles of the jaw, and elevators of the hyoid bone, may involve the lingual and facial blood-vessels, the hypoglossal nerves, and the submaxillary glands and ducts. They may penetrate the floor of the mouth to a greater or less extent, and partially or even completely sever the tongue. Such wounds are very dangerous. In nine out of eleven cases of which I have particulars, they proved fatal. They are usually attended by profuse hæmorrhage. They gape widely when the head is thrown back. Saliva, mucous discharges, and alimentary materials, attempted to be swallowed, escape freely. Great dryness of the fauces and thirst are usually complained of. Articulation may be impaired, and vocalisation enfeebled. Death may ensue from loss of blood, from obstruction of the larynx by blood coagulated in the back of the mouth or upper part of the pharynx, or, as in the case already referred to, and in others that might be quoted, the posterior portion of the divided tongue may fall backwards and produce suffocation.

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* See Horteloup, op. cit. p. 77 and p. 117.

† *Edin. Med. and Surg. Journal,* vol. xvi. p. 353.

b. Wounds through the thyro-hyoid membrane penetrate into the pharynx, and may partially or completely sever the epiglottis, the aryteno-epiglottidean folds of mucous membrane, and even the arytenoid cartilages or vocal cords. The superior thyroid vessels, and possibly the lingual, are liable to be involved, and the superior laryngeal nerves may be injured. These wounds are much more common than the preceding, and perhaps are somewhat less dangerous. They do not gape so widely, but permit the partial or entire escape of nutriment, &c. They are almost always attended by great difficulty in swallowing, on account of the convulsive cough produced by the irritation of the food in its passage over the imperfectly protected laryngeal orifice. They are liable to be very speedily followed by great difficulty in breathing, spasmodic fits of suffocative cough, complete loss of voice, and lividity of the face. Such symptoms indicate inflammation and œdema about the glottis and upper part of the larynx; and unless relief is afforded by appropriate treatment, death ensues. Sometimes a detached or partially detached portion of the epiglottis, or some other structure, gets into the glottis, and more or less seriously impedes respiration.

c. Wounds which penetrate the larynx are, as a rule, very dangerous; but more so perhaps on account of the after-complications to which they are especially liable than from their immediate effects. They are not usually attended by much hæmorrhage. The important blood-vessels most likely to be involved are the superior thyroid. Deep gashes which happen to traverse either the crico-thyroid or the crico-tracheal membrane, may reach the carotids and jugulars more easily than wounds made with equal force across other parts of the front of the neck. Breathing, swallowing, and vocalisation are affected in a manner and to an extent varying with the precise seat of the injury and the structures involved. Sometimes the symptoms are apparently very anomalous. A wound through the upper part of the thyroid cartilage may involve the arytenoid cartilages; and separated portions of one or the other may occlude the glottis, or becoming necrosed may subsequently lead to serious, if not fatal, complications. Inflammation and œdema about the glottis are very liable to occur; and the inflammation may rapidly extend along the trachea and bronchi to the lungs. If the earlier dangers are escaped, others may arise at more remote periods from exuberant growth of granulations, and thickening of the mucous membrane in the neighbourhood of the wound, or still later, from contraction of the cicatrices.

A patient was recently under my care in Guy's Hospital, whose larynx had been wounded by a bayonet during the American War. The wound healed very slowly; but at last he thought himself well, although his voice was much impaired. After a time he began to suffer from difficulty of breathing, which gradually but certainly increased. When he came under my care, his voice was reduced to a whisper, and, as he said, it was 'hard work to get a breath.' Laryngoscopic examination showed great and irregular constriction of the upper part of the larynx. The vocal cords could not be seen. One night, suffocation impending, tracheotomy was performed. Great relief immediately followed, and under subsequent treatment he became able to breathe to some degree through his larynx, and his voice was much improved.

Punctured wounds through the thyroid cartilage occasionally penetrate between the vocal cords, or injure one or both of them. In such cases œdema about the glottis almost invariably occurs, and produces death by suffocation.

Sir C. Bell * mentions an instance in which a young woman, who had inflicted a wound in this situation with a penknife, was suffocated some months afterwards by the exuberance of the granulations which arose from the edges of the wound, and filled up the aperture of the glottis.

When the cartilages of the larynx are divided entirely across (which, however, rarely happens), the upper portions are drawn upwards by the elevator muscles, and the lower portions downwards by the depressors. Thus a large gaping wound is produced, which is usually complicated with injury of the anterior wall of the pharynx.

Ordinarily, wounds of the larynx do not gape much; and the free escape of air, blood, mucus, and pus, may be hindered. In such cases the occurrence of emphysema, and the entrance of blood, &c., into the air passages, are proportionately favoured.

d. Wounds which divide the trachea are usually attended by considerable hæmorrhage; and there is great danger of the entrance of blood. The superior and inferior thyroid arteries and the thyroidea ima, when present, as well as the thyroid veins and superficial jugulars, are liable to be involved. The thyroid body may be implicated, and if so, it bleeds freely. The recurrent laryngeal nerves are sometimes injured. If the trachea is only partially cut across, the edges of the wound separate only slightly from each other, and are easily kept in contact by bending the head and neck towards the chest. Sometimes, however, the trachea is completely divided. In such case the two ends separate very widely from each other, and the lower portion is drawn downwards at each inspiration towards the thorax, and more or less under cover of the neighbouring parts. Thus respiration becomes seriously impeded.

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* Op. cit. vol. i. p. 45.

Richet * records a remarkable instance in which the trachea was obliquely divided through four or five of its rings. The separation between the two portions measured more than two inches, and was increased by about another half an inch during inspiration. When left to itself the lower portion plunged down behind the sternum almost into the mediastinum; it could be seen to descend still lower at each inspiration, and to ascend again during expiration. All attempts to secure union failed. Suffocation impended when the wounded surfaces were brought together. The patient ultimately recovered, but an opening into the trachea remained.

When the trachea is completely divided transversely, the œsophagus rarely escapes. Sometimes it is wounded, occasionally entirely severed. Wounds of the œsophagus may be recognised by examination with the finger; their existence is indicated by the escape of materials swallowed through the wound. But, as already stated, such escape may sometimes take place although the gullet is uninjured.

In cases in which both the trachea and œsophagus are divided, the danger to life is necessarily very great. But even under such circumstances recovery may take place, as for example in the instance already quoted (p. 445).†

Treatment.—1. When called to attend a case of wound of the neck, the surgeon's first care must be to *arrest hæmorrhage.*

Venous hæmorrhage, as a rule, may be effectually stopped by pressure; but occasionally it may be necessary or desirable to apply one or more ligatures. If the external jugular or any other superficial vein is wounded, gentle but continued pressure with the finger, beneath which a small pad of lint has been placed, is generally all that is required, even though the bleeding has been considerable. If the internal jugular is wounded, the hæmorrhage is profuse, and very rapidly proves fatal, unless prompt assistance is afforded.

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* *Gazette des Hôpitaux*, 1855, p. 35.

† In Hennen's *Military Surgery*, 3rd Edit., 1829, p. 368, is a case communicated by Dr. James Johnson. A Malay cut his comrade's throat while asleep. The windpipe was divided, and also half the œsophagus. The sufferer was supported by enemata, and gradually recovered.

Mr. Bryant * has recorded the case of a little girl, nine years of age, who stumbled whilst carrying a chamber utensil in her hand, and fell on the broken china. The right internal jugular vein was wounded, and such profuse hæmorrhage followed, that she died five minutes after her admission into Guy's Hospital.

If it is evident that some large vein is injured, but the precise source of the bleeding cannot be at once made out, the wound should be immediately plugged with small pieces of sponge, and pressure with the finger applied as long as necessary. The pressure may be maintained by means of carefully adjusted strips of adhesive plaister. But this treatment is sometimes followed by serious results.

A man was admitted into St. George's Hospital on July 14, 1847, who had cut his throat with a penknife. On the left side of the neck, a little below the cricoid cartilage, was a wound about an inch and a half in length, extending transversely across the space between the sterno-mastoid and trachea, partially dividing the muscles in this situation, and passing for some distance under the skin towards the clavicle. There had been profuse hæmorrhage, and dark blood was still welling up. The wound was plugged with sponges, and pressure with the fingers applied. At 1 P.M. the wound was dilated upwards and downwards; no bleeding vessel was discovered, but it was evident that the bleeding proceeded from the lower end of the wound. About half a pint of blood was lost before the sponges were reapplied. The wound gradually suppurated. When the last sponge had been removed a deep granulating cavity was seen, with a slough in the direction of the sheath of the vessels. On July 22, at 5 P.M., hæmorrhage suddenly recurred to an alarming extent, and the patient died in the evening. On inspection a slough was found completely destroying the front wall of the internal jugular vein for three inches of its extent. The posterior half only of the vessel remained. The sloughing extended upwards from about an inch above the junction of this vein with the subclavian. The anterior wall of the common carotid artery had also been wounded; the opening was small, and was blocked up by lymph and coagulum, which were intimately adherent to the edges of the wound.

If the hæmorrhage is not speedily and satisfactorily stopped by pressure, and its precise source can be discovered, the safest plan is to ligature the vein above and below the wounded part.†

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* *Pathological Transactions*, vol. viii. p. 101.

† See Gross on 'Wounds of the Internal Jugular Vein,' *Amer. Jour. Med. Sciences*, Jan. 1867. In this elaborate article numerous cases are quoted. A case in which the internal jugular vein was partially divided with a razor, and the patient saved by securing it with a ligature, is given by Dr. Morgan of Geneva, *Amer. Jour. Med. Sciences*, vol. xviii. p. 330. He refers to two other successful cases of ligature of this vessel, by Dr. Stevens of New York, and Dr. Gibson of Philadelphia.

If one of the large veins, as the jugular or subclavian, should be slightly wounded on one side, according to Roser, it may be better to close the opening by means of a fine suture, rather than to ligature the whole vessel. Or a tenaculum may be passed through the edges of the opening, and a ligature applied. Cases in which this proceeding was adopted with success are referred to by Legouest.*

Arterial hæmorrhage demands for its arrest the promptest measures. In wounds of the carotids or their principal branches, death commonly ensues before surgical aid can be obtained.

During the summer of 1859, one of the inmates of St. George's Hospital committed suicide by cutting her throat. She was almost immediately seen by the House Surgeon, but had already ceased to breathe, and was quite pulseless. There was a deep gash in the throat, dividing the left common carotid artery, and wounding both internal jugular veins.

But it must not be supposed that even severe wounds of the carotids are of necessity *immediately* and invariably fatal. Numerous cases to the contrary are on record.†

If in a case of wound of the neck, accompanied by free arterial bleeding, assistance should arrive before the patient is dead, pressure should be at once applied over the wound; or the finger should be thrust into the wound, and made to press in the direction from whence the bleeding comes; or the common carotid should be compressed against the transverse processes of the fifth and sixth cervical vertebræ. The wound may then be enlarged, if needful, and the wounded vessel sought. If found, the vessel must be secured, both above and below the wound, by ligature or by torsion. The latter method may be less generally or less readily applicable, but it has the advantage of leaving no dangling threads which the determined suicide may tear out. If the wounded vessel cannot be found without prolonged and careful dissection, as sometimes happens, it is better to apply a ligature at once to the common carotid.‡ Before doing so, however, it should be ascertained that the bleeding is stopped by compressing this vessel. The results of ligature of the common carotid on account of hæmorrhage from wounds cannot be considered as very unfavourable, if regard be paid to the extreme danger of the conditions under which the operation has been performed in such cases.

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* Op. cit. p. 428.

† See Taylor's *Medical Jurisprudence*, 1865, p. 513. Larrey, *Cliniq. Chir.* t. ii. p. 128.

‡ Le Gros Clark refers to two such cases under his care, in each of which a good result was obtained. Op. cit. p. 222; see *British Medical Journal*, Aug. 21, 1869. Also *Med.-Chir. Trans.* vol. xxx. p. 15.

Dr. Pilz * in his analysis of 586 cases of ligature of the common carotid gives forty-four cases of punctured and incised wounds in which the operation was performed. In twenty cases recovery ensued; in twenty-four death. Out of eighty-five cases of gun-shot wounds and injuries by military arms, however, only thirty-one recovered.

Lacerated and punctured wounds involving the carŏtid arteries are less likely to prove immediately fatal than incised wounds. Ample time for the application of a ligature is sometimes afforded.

Abernethy has related a case in which the internal carotid, and all the branches in front of the external carotid, were wounded in a man who was gored in the neck by a cow. Death did not directly follow, and there was time to have recourse to the ligature.†

A remarkable case of punctured wound of the carotid came under my observation two years ago. A little girl seven years of age was playing in the room where her father was preparing hydrogen gas. An explosion took place, and a triangular portion of one of the glass bottles was driven into her neck. Profuse hæmorrhage immediately occurred, but whether venous or arterial could not be made out from the description given. A piece of lint was applied, and she was brought up from Greenwich to Guy's Hospital, and admitted under the care of Mr. Hilton. On admission the child was cold and blanched, with feeble pulse; but bleeding had entirely ceased. There was a wound about an inch in length in the left carotid region. On the eighth day after the accident, hæmorrhage recurred, and the common carotid was tied. Nine days later bleeding to a slight extent took place, but was arrested by plugging the wound with sponge. Repeated epistaxis occurred during the following days, and weakened the child perceptibly. The sponges became very offensive; but there was no further bleeding from the wound for eighteen days. Then a considerable quantity of blood was lost. The child gradually sank and died ten day later, or rather more than six weeks after the accident. On dissection, the common carotid was found to have been punctured in front and behind. The sharp point of the fragment of glass must have traversed the interior of the artery. Behind the wounded vessel was an abscess implicating the sympathetic nerve.‡

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* Dr. Pilz, *Archiv. f. Klinische Chirurgie*, ix. 1868. Schmidt's *Jahrbücher*, No. 7, 1868. Quoted in *Half-Yearly Abstract*, 1868.

† *Surgical Works*, vol. ii.

‡ Instances of wounds of the carotid not proving fatal are recorded by Larrey and other surgeons. See *London Medical Gazette*, vol. viii. p. 250. *Nouveau Dict. de Méd. et de Chir.* art. Carotide. In his *Clinique chirurg.* t. ii. p. 128, Larrey records the case of Arrighi, afterwards Duke of Padua, whose carotid was torn by a bullet. A soldier near put his finger into the wound, and stayed the bleeding until Larrey's aid was obtained.

2. In wounds of the neck which involve the air passages, death is almost as likely to result from suffocation as from loss of blood. To remove, therefore, or to obviate as far as possible any impediment to free respiration, may require as much promptitude and skill on the part of the surgeon as the arrest of hæmorrhage. It may be necessary, without a moment's delay, to clear clots of blood from the back of the mouth or pharynx, or to resort to artificial respiration to aid the expulsion of blood, or even to suck it from the trachea. It is very rarely, however, that any such measures can be carried out in time to be of avail; unless indeed, as sometimes happens, the occasion should arise during the performance of a surgical operation.

If a portion of the divided tongue should impede respiration, it must be at once drawn forwards, and prevented from again being retracted or falling back by means of ligatures passed through it. This was successfully accomplished in a case of cut throat, recently under the care of Mr. Cock, in Guy's Hospital.

If a severed portion of the epiglottis should hang loose, it may be removed; or an attempt may be made to secure it in position by fine sutures. The former is probably the safer plan, being less likely to be followed by dangerous inflammation and œdema about the entrance to the larynx. Numerous instances show that the loss of a portion of the epiglottis, whether by injury or disease, does not necessarily entail any serious consequences.*

3. When all bleeding has ceased, and no immediate hindrance to respiration exists, the cut surfaces of the wound should be brought together. This may generally be accomplished effectively, and with the greatest safety, by putting the head and neck into proper position. The patient being in bed, the shoulders should be well raised by pillows, and the head and neck bent forwards so far as may be necessary to keep the surfaces of the wound in good apposition, without impeding respiration. But in some cases the patient is absolutely unable to breathe except through the wound; and any attempt to bring the parts closely together involves the risk of suffocation. To maintain the head in position, bandages may be passed from each side of a firm nightcap to a roller applied round the chest; or sand-

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* See cases quoted by Horteloup, op. cit. p 58.

bags may be arranged on each side of the head and neck. As a general rule, neither sutures nor adhesive plaisters should be used. They are at best needless in most cases, for primary union can scarcely be expected; and, indirectly, they may in various ways prove sources of danger. For example, if the edges of the wound are closely united, and bleeding should recur, the blood, instead of escaping externally, may trickle into the air passage, and accumulating there may cause suffocation. This is especially liable to occur while the patient is insensible, or faint from loss of blood, and unable to make the necessary effort to expectorate. At a later period purulent discharges, if they cannot find free exit externally, may pass into the air passage, or otherwise give rise to serious trouble. Again, inflammation and œdema of the neighbouring parts and of the mucous membrane of the larynx may ensue. Under such circumstances viscid mucus collects, and, if it cannot be expelled through the wound, obstructs the air passages, and increases the existing difficulty of breathing. Lastly, closure of the wound by sutures is likely to be followed by emphysema. In some cases, however, both plaisters and sutures may be employed with safety and advantage, at a period when the surfaces are healthily granulating. Indeed, Nélaton * recommends, under such circumstances, the insertion of several sutures in all cases, in order to prevent the turning in of the edges, and to avoid the risk of a permanent fistula. But it sometimes happens that the discharges become confined, or great pain is occasioned, and the sutures have to be removed; or they may be torn out during the violent coughing which so commonly occurs.

In certain exceptional cases sutures may be necessary from the first. Thus, if the cartilages of the larynx are cut in several places, and the different pieces are much separated from each other, they may be joined by one or more sutures passed through the cellular tissue surrounding them. If complete division has been effected between the thyroid and cricoid cartilages, and these parts are separated from each other, one or two sutures may be used to approximate them. And if the trachea is completely divided across, it may be necessary to have recourse to one or more sutures. In every case, however, it is better to try the effect of position first; because, if the

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* *Éléments de Pathologie chirurgicale,* t. iii. p. 340.

divided parts have not separated to any great extent, sufficient approximation may be thus accomplished. If sutures are used, and respiration should become obstructed, or if the cellular tissue around the wound becomes emphysematous, they must be instantly removed.

The patient should be surrounded by a moderately warm and moist atmosphere, and the wound lightly covered by a strip of wet lint or linen. A skilful nurse should be in constant attendance to prevent any fresh suicidal attempt, and to clear away the blood and mucus that may from time to time collect in the wound. Expectoration, if very difficult, may be rendered easier by closing the wound with the fingers at the moment the effort is made.

Every means should be adopted to favour granulation and cicatrisation of the wound.

The respiration should be carefully watched. Difficulty of breathing may arise at any period from one or other of the various causes already specified, and require immediate relief. Care should especially be taken to allay as far as possible all symptoms indicating incipient inflammation of the larynx or trachea. Such symptoms may arise very soon after the infliction of the injury. If suffocation impends, and is not at once relieved by clearing out or enlarging the wound, or by introducing a tracheotomy canula through it, a fresh opening into the air passage must be made below the wound, and a canula inserted. Some surgeons consider that tracheotomy may be advantageously performed in any case of extensive transverse wound involving the air passage, as soon as all hæmorrhage has ceased, and the shock of the injury has been recovered from. When this has been done, the edges of the wound may be united without risk of suffocation; and after the wound is healed, the canula may be withdrawn, and the opening in the trachea closed.

Bronchitis, as already stated, very often occurs, and if unchecked, is soon followed by pneumonia or pleurisy. Every care must be taken to obviate this source of danger by regulating the temperature and moisture of the atmosphere about the patient, and by preventing the ingress of irritating discharges, and favouring their expectoration.

When the pharynx or œsophagus is laid open, and especially when the latter tube is completely divided, great separation of the edges of the wound takes place during swallowing, and the ingesta partially or entirely escape through the wound. In such case, the elastic tube of a stomach-pump, or a common elastic catheter of large size, should be used to convey nourishment to the stomach. The tube should be introduced through the mouth,—not through the nose, as some surgeons have recommended,—and passed into the œsophagus a short distance beyond the wound. It may be used two or three times daily. The tube should on no account be passed through the wound; for, if this be done, union is very seriously interfered with. Before any fluid nourishment is poured through it, care should be taken to ascertain that the tube has not been passed into the trachea. This may be ascertained by placing a lighted taper at the end of the tube, and observing if the flame is affected. It sometimes happens that the introduction of the tube is very distressing to the patient, and produces much irritation about the wound: under these circumstances, nutrient enemata must be administered. When swallowing is again attempted, the patient should be directed to lean somewhat backwards, and to swallow small portions very slowly.

The general condition of the patient is often such as to require the most careful management, and to occasion the gravest anxiety. In some cases there is low muttering, in others furious delirium, consequent upon habits of intemperance. Sometimes periods of intense excitement are followed by corresponding periods of exhaustion. Sometimes unvaried depression and despondency prevail. Such symptoms may prove more difficult to combat than most of those more directly associated with the effects of the wound; and, when they occur, speedy death too often results, even in cases in which the injury inflicted has been comparatively trifling.

As a general rule, the patient should not be kept low. Plenty of nutritious food, and wine or spirits must be given, according to the circumstances of the case, due care being taken not to over stimulate. The danger of exciting inflammation by food and stimulants is less than the risk that the patient may sink exhausted from want of sufficient nutriment.

Exuberant granulations obstructing the air passages have already been referred to as occasionally becoming developed around the wound. Such granulations are sometimes met with in cases of tracheotomy.* They are best treated by the repeated application of solid nitrate of silver. In some instances it may be necessary, if possible, to open the trachea lower down.

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* See paper by T. Smith, *Medico-Chirurg. Trans.* vol. xlviii. p. 227.

Constrictions of the larynx or trachea occurring during cicatrisation, or from subsequent contraction, may render necessary the immediate performance of tracheotomy. After this has been done, the constrictions, in some cases, may be dilated by the passage of bougies. In other cases, the use of the knife is also required. Several remarkable instances have been published, in which more or less successful results have been obtained.*

Laryngeal and tracheal fistulæ.—Fistulous openings occasionally, though very rarely, remain after general healing has taken place. They are most likely to result in cases in which considerable portions of the air tube have been destroyed, or in which constrictions have occurred higher up. If no constriction exist, or after any previously existing constriction has been satisfactorily dilated, the fistula may generally be closed by paring the edges and bringing them together. Sometimes it may be necessary to detach the skin from the deeper structures to some slight extent round the opening, or to make lateral incisions to facilitate the drawing together of the margins. The sutures should be pretty close, and should include so much tissue as to render the occurrence of emphysema improbable. After the operation, gentle pressure should be applied, especially during coughing. In the case of a very large opening, skin may be taken from the most convenient neighbouring part, and adapted as may be requisite. No operation of this kind should ever be attempted until it has been absolutely ascertained that respiration will not be impeded by closure of the fistula.†

OTHER INJURIES OF THE PHARYNX AND ŒSOPHAGUS.

The pharynx and œsophagus may be wounded from within by sharp-pointed instruments, or other foreign substances thrust through the mouth.

If in an injury of this kind the side of the pharynx is penetrated, dangerous or even fatal consequences may arise from implication of one of the larger vessels.

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* Liston, *Edin. Med. and Surg. Journ.* No. xciv. p. 118, and *Elements of Surgery*, 2nd ed. p. 435. Horteloup, op. cit. p. 123.

† See an excellent case by M. Le Fort, full details of which are given by Horteloup, op. cit. p. 127 et seq.

The following case illustrates this form of injury, and the treatment it may be necessary to adopt. A boy, aged seven, was admitted into St. George's Hospital, May 12th, 1850. A week previously, he fell while holding the sharp end of a parasol in his mouth. The point was forcibly thrust to the back of the fauces, and very nearly made its reappearance through the skin at the side of the neck. Considerable hæmorrhage took place at once, and recurred at night. About the seventh or eighth day a slough came from the interior of the mouth; and arterial hæmorrhage to the extent of about five ounces occurred. The bleeding was stopped by pressure applied externally; and the boy was soon afterwards brought to the hospital. On examination, a swelling about as large as half a hen's egg was found below and a little behind the left ear, and the skin for some distance around was discoloured, as from extravasation of blood. Fluctuation was detected on the summit of the swelling. This being opened, pus with much blood clot escaped, but no hæmorrhage ensued. Two days afterwards a gush of arterial blood followed a fit of coughing. Mr. H. C. Johnson cut down upon and tied the common carotid artery. No unfavourable consequences ensued. Nine days afterwards the ligature was found loose; it soon came away. The wound healed; and on June 12th, twenty-seven days after the operation, the child was discharged in a very favourable state.

In some cases portions of food or other contents of the pharynx may pass through the wound and set up inflammation, followed by abscess.* In other cases fragments of the foreign substance which has produced the wound may be broken off, and remain impacted, and give rise to similar results.†

Slight wounds of the œsophagus, such as may be produced during the passage of hard, sharp substances towards the stomach, usually heal without serious symptoms. Dangerous consequences, however, may ensue if a wound of this portion of the gullet is accompanied by severe injury of neighbouring parts, as is shown by the following case, related by Dr. Parkes.‡

A young, healthy, athletic juggler, on the evening of January 24, was exhibiting the trick of swallowing a sword, made of iron, about two feet long, three-quarters of an inch broad, and round and blunt at the end. When he had passed the sword nearly to the root of the neck, he felt it strike against some obstacle, past which he violently pushed it. He immediately withdrew the sword, gave a sudden leap in the air, then fell and fainted. When he recovered, he vomited violently. The vomited matters consisted of the contents of the stomach, without the slightest tinge of blood. Intense pericarditis, marked by characteristic symptoms, came on forty minutes after the accident, and he died in the evening of the second day. The sword had penetrated the anterior wall of the œsophagus five and a half inches below the pharynx, and passed into the pericardium. Lymph was effused over the whole parietal and visceral pericardium. The important blood-vessels and other organs in the neighbourhood were uninjured.

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* See C. H. Moore, *Lancet*, 1864, vol. ii. p. 287.

† See Vincent, *Med.-Chir. Trans.* vol. xxix. p. 38. Larrey, *Clinique chirurgicale*, t. ii. p. 134.

‡ *Path. Trans. London*, 1848–9, p. 40.

In some instances the walls of the œsophagus have been perforated by the surgeon, while attempting to pass a bougie or tube, in certain diseased conditions of the parts. In some such cases the instrument has passed into the mediastinum; in others, even into the pleural cavity.

In all cases, in which there is reason to suspect the existence of any serious internal wound of the gullet, solid food should be interdicted, and only the blandest fluids swallowed. Indeed, it may be better that no attempt to swallow should be made until time has been allowed for healing to take place to a certain extent.*

Rare instances are on record in which the œsophagus has been ruptured during violent vomiting.

Boerhaave † relates the case of the Baron Vassenaer, who habitually made himself vomit after excess at table. At last, while vomiting very violently, he was seized with sudden pain, and died in eighteen hours. Transverse rupture of the œsophagus (which was otherwise healthy) was found three fingers breadth above the diaphragm. A recent case is narrated by Dr. Griffin ‡ of Banbury, in which the œsophagus of a healthy man was ruptured during violent vomiting.

Other Injuries of the Air Passages by Mechanical Violence.

The following injuries, singly or complicated one with another, may be caused by manual compression, blows, kicks, falls upon projecting corners or edges, or by hanging, or other modes of strangulation.

1. *Contusions.*—A blow upon the larynx may prove suddenly fatal by shock, or by arrest of respiration from spasm of the glottis. If life is not altogether extinct, laryngotomy should be at once performed, a tube introduced, and artificial respiration kept up as long as needful, or while hope remains.§ Short of an immediately fatal result, insensibility of longer or shorter duration is a common effect of a blow or other sudden pressure upon the air passage. The victims of the street-garotter are thus rendered unconscious before they are robbed, and often

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* See a remarkable instance of a partially cicatrised wound of the œsophagus burst open by solid food which escaped into the thoracic cavity. Larrey, *Clinique chir.* t. ii. p. 161.

† Boerhaave. Quoted by Horteloup, op. cit. p. 23.

‡ *Lancet,* Sept. 4, 1869, p. 337.

§ See a case by Liston in the *Edin. Med. and Surg. Journal,* vol. xix. p. 570.

remain so for some time afterwards. Sometimes the symptoms which follow a blow upon the larynx are less severe, and may be subdued without having recourse to any operative measures.

The symptoms which commonly attend contusions of the larynx are great pain and tenderness about the seat of the injury, more or less swelling in the neighbourhood, enfeeblement or total loss of voice, with little or no difficulty of breathing. Rest of the parts, and the application of leeches and warm anodyne fomentations, constitute the treatment generally required. Antimonials and mercurials may be useful in some instances.

2. *Fracture of the hyoid bone.*—Fracture of the hyoid bone is a rare but well recognised accident. It is usually caused by direct violence, but in some instances has been attributed to muscular action.* It is occasionally found to have occurred during execution by hanging, but not so frequently as some have supposed.† The parts usually injured are the cornua, at or near their junction with the body. One or both may be broken. Much displacement of the fragments generally occurs. The symptoms are pain in the neck, inability to turn the head, dysphagia, or even total inability to swallow. The voice is hoarse, the patient having great difficulty and pain in speaking. Symptoms of suffocation occasionally occur, or may be produced by simple protrusion of the tongue. On examining the throat externally, crepitus, or some irregularity may be detected; and on looking into the mouth, not unfrequently ecchymosis and swelling of the mucous membrane may be found. The fragments occasionally perforate the mucous membrane, and more or less bleeding may occur.

In an interesting monograph on 'Diseases and Injuries of the Hyoid Bone,'‡ Gibb has brought together more or less complete details of thirteen cases of fracture. In four of these the right cornu was broken, in five the left; and in one (that of a child) the middle of the body of the bone was broken. In two the precise seat of the injury is not stated. Two of the cases terminated fatally.

Treatment.—The displaced fragments must be restored to their proper position. This may be effected by passing the finger of one hand into the throat, and by the other hand manipulating the bone externally. The patient should be kept quiet, every attempt at speech avoided, and antiphlogistic regimen adopted. Inflammation may be relieved by the application of leeches. If great difficulty of breathing should supervene, laryngotomy must be performed. If the patient cannot swallow, or finds great difficulty and pain in doing so, the use of the œsophageal tube is requisite. If the passage of this tube produces much pain or inconvenience, nutrient enemata must be administered.

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* *British and Foreign Medico-Chirurgical Review,* vol. viii. p. 549.

† Casper, op. cit. vol. ii. p. 174. Taylor, *Medical Jurisprudence.*

‡ *On Diseases and Injuries of the Hyoid or Tongue Bone,* by G. D. Gibb, M.D. Churchill, London, 1862.

The following case described by Lalesque[*] affords a good example of fracture of the hyoid bone. A marine, aged sixty-seven, had his throat violently clenched by the hand of a powerful adversary. At the moment there was very acute pain, and the sensation of a solid body breaking. The pain was aggravated by every effort to speak, to swallow, or to move the tongue; deglutition was impossible, articulation indistinct, and he was unable to open his mouth without a great deal of pain. The left horn was broken near the body of the bone, and had pierced the mucous membrane, and given rise to considerable hæmorrhage. He was fed by an œsophagus-tube for twenty-five days, and ultimately recovered.

Cases have occurred, in which detection of the fracture has been less easy than might have been expected.

The following is an illustration: A labourer, aged sixty-three, fell from a waggon on his face. Much blood issued from his mouth. He complained of severe pain in the neck, and was unable to turn his head. His voice was hoarse and difficult; he could not swallow; on attempting to drink, violent coughing was excited, and the fluid was rejected. The tongue was freely moveable, and there was no pain on depressing it. The epiglottis did not appear to cover the larynx completely, nor to be in its exact position. Neither crepitus nor unusual mobility could be perceived about the hyoid bone, which seemed to preserve its continuity. The case was supposed to be one of injury of the laryngeal nerves and muscles and of the pneumogastric nerve. Medicine and food were administered by an elastic tube. The pain in the neck subsided, and its motions were restored. A hectic cough from which he had long suffered remained. The cough increased, the voice became scarcely audible, and the patient died exhausted eleven days after the occurrence of the accident. On dissection, fracture of the hyoid bone was found. 'One of the large cornua was broken and had become firmly embedded between the epiglottis and rima glottidis, inducing the raised position of the epiglottis, loss of voice, and difficulty in swallowing.' [†]

3. *Dislocation of the hyoid bone.*—Gibb has recorded [‡] in the

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[*] *Journal univ. et hebdom.*, mars 1833. Also *American Journal Medical Sciences*, vol. xiii. 1833, p. 250.

[†] *Brit. and Foreign Med.-Chir. Review*, 1851, vol. viii. p. 549. Schmidt's *Jahrbücher*, vol. lxviii. p. 215.

[‡] Op. cit. p. 20, and *Trans. of the Path. Soc. London*, vol. x. p. 66.

following words a case of dislocation of the hyoid bone in a patient under his care.

> The patient, a man aged forty-five, 'would feel a sudden click in the *left* side of his neck, which produced a sensation as if something was sticking in his throat. On examination, this appeared to me to depend upon a displacement of the left horn of the hyoid bone, and was generally reduced by throwing the head backwards, towards the *right* side, so as to stretch the muscles of the neck, and then suddenly depressing the lower jaw, and so putting the depressors of the hyoid bone into operation. He died some years after of pulmonary consumption. On examining his throat after death, I found a sort of pouch, which answered the purpose of a synovial capsule, embracing the horns of the left thyro-hyoid articulation. It was filled with a clear fluid, had a comparatively large rhomboid sesamoid bone developed in its outer wall, and permitted an extraordinary amount of motion.' This was the fourth case of the kind which had come under the notice of Gibb. All the patients were males. He subsequently met with a fifth case in which the patient was a female.

Reference is made in the work quoted to a paper, read in 1848 before the Parisian Medical Society, by Dr. Ripley of South Carolina, on 'Dislocations of the Os Hyoides, especially illustrated in his own person, and the manner of reducing them.' The latter process consisted 'in throwing the head backwards as far as possible, so as to place the muscles of the neck on the stretch, then relaxing the lower jaw, at the same time gently pressing or rubbing over the displaced part, when the displacement becomes reduced after a few attempts with a click.'

Two cases of dysphagia described by Abercrombie* are considered by Gibb to have been 'examples of double displacement of the thyro-hyoid articulation.'

4. *Fractures of the cartilages of the larynx.*—The cartilages of the larynx may be broken by a fall against some projection, or by a blow, or by forcible compression by the hand of an adversary, or by some other of the various modes of strangulation. This lesion is most likely to occur after ossification has taken place, but it may be met with during childhood.† The fragments may be so displaced as to encroach upon the cavity of the larynx or pharynx; and occasionally the mucous membrane is perforated. Injuries of this kind are of extreme danger to life, on account of the various obstructions to respiration to which they may give rise. Such obstructions may

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* *Diseases of the Stomach,* 2nd edit. 1830, p. 102.

† Out of twenty-seven recorded cases analysed by Hunt, five were in children. *American Journal of the Medical Sciences,* April 1866, p. 378.

be caused either immediately, by displacement of the fractured portions, by spasm of the glottis, or by entrance of blood into the air passages; or subsequently, by inflammation and œdema of the lining membrane of the larynx, or by local or general emphysema.

In an excellent article recently published, M. Hénoque * analyses fifty-two cases collected from various sources. To these I am able to add ten, two of which have been under my own care. It is worthy of special note, that every case in which the cricoid was fractured proved fatal.

The following is a summary of the sixty-two cases.

Cartilages fractured.	No. of cases.	Deaths.	Recoveries.
Thyroid only	24	18	6
Cricoid only	11	11	
Thyroid and os hyoides	4	2	2
Thyroid and cricoid	9	9	
Thyroid, cricoid, and os hyoides . . .	2	2	
Thyroid, cricoid, and trachea	2	2	
Cricoid and trachea	2	2	
Cricoid, trachea, and os hyoides . . .	1	1	
'Fractures of larynx'	7	3	4
	62	50	12

Fractures of the laryngeal cartilages are accompanied more or less constantly by the following signs and symptoms. The general contour of the neck is altered: there is usually flattening; but, in cases in which lateral compression has caused the injury, there may be undue prominence of the pomum Adami. Ecchymosis, and swelling of the neck due to extravasation of blood, or at a later period to inflammatory exudation, are commonly observed. The cartilages, or portions of them, are abnormally moveable. Sometimes crepitation may be detected; but this must be carefully distinguished from the false crepitation produced by pressing the cornua of the thyroid

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* *Gazette hebdomadaire*, September 25 and October 2, 1868. The following contributions are reviewed:—Gurlt, *Handbuch der Knochenbrüche*, vol. ii. p. 316. W. Hunt, *Amer. Journ. of Med. Sci.* April 1866. Wales, *Amer. Journ.* January 1867. Hamilton, *Amer. Journ.* April 1867. *Soc. Anat.* December 1866, p. 393, 518. Fredet, *Considérations sur les Fractures traumatiques du Larynx* (Paris, Delahay, 1868). Keiller, *Edin. Med. Journ.* 1856, p. 527, 824. Helwig, in Casper's *Vierteljahrschrift*, 1861, p. 342.

For other cases see *Dublin Quart. Journ.* May 1869; *Lancet*, 1869, p. 707; *Gazette des Hôpitaux*, 1868, Nos. 90 and 91.

cartilage against the spinal column. Emphysema may occur if the mucous membrane is lacerated.

The patient complains of great pain, either constant, or produced or aggravated by pressure or attempts at swallowing or speaking. There is almost always more or less difficulty of breathing, accompanied by lividity of face, coldness of skin, and smallness of pulse. The dyspnœa may be caused by displacement of the cartilages, or abnormal mobility of the points of attachment of the vocal cords; or by submucous effusion of blood; or by extravasation of blood external to the larynx. In a case recorded by Mr. Stokes,* blood was effused in the neighbouring parts to such an extent as to push the larynx over to one side. Sometimes difficulty of breathing comes on quite suddenly, and very severely, several days after the injury. In such case it may be due to accidental displacement of some fragment, or to the supervention of acute œdema.

Convulsive cough and expectoration of frothy blood may immediately follow the injury. At a later period there may be copious expectoration of very offensive pus; and occasionally, even necrosed portions of the fractured cartilages may be coughed up. The voice may be affected to a variable extent. Sometimes it is hoarse; sometimes enfeebled; sometimes altogether lost.

Fracture of the laryngeal cartilages, however, may occur without giving rise to any very marked symptoms, and without being attended by displacement or deformity. A case of this kind is recorded by Gibb.

Treatment.—In simple fractures with little or no displacement, and in which the breathing is easy, the parts may be steadied and supported by small pads of lint and strips of adhesive plaister. The act of swallowing should be carefully watched, and interdicted for a time if it should occasion manifest displacement of the fractured parts. Local antiphlogistics or leeches may be applied. If there is great and continued dyspnœa from the first, and especially if there is much deformity of the larynx, tracheotomy should be performed at once. If the first difficulty of breathing should have subsided, the propriety of operating may be doubtful; but experience shows that delay in such cases may be emphatically dangerous.† The dyspnœa may recur suddenly at any moment, and almost without warning; and death may ensue. Tracheotomy must be insisted on whenever suffocation becomes imminent, at whatever period it may be. The operation ensures at any rate temporary safety; and it may afford opportunity for the restoration of the displaced parts to proper position. Such restoration may be attempted by external manipulation, aided by a finger introduced through the mouth, or by a probe passed through the opening made in the trachea.

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* *Dublin Quarterly Journal of Med. Science*, May 1869.

† See cases recorded by Fredet, *Gazette des Hôpitaux*, 1868, Nos. 90 and 91. Also Fredet, op. cit.

In eight out of the twelve cases above summarised, in which recovery took place, life was manifestly saved by the timely performance of tracheotomy, or laryngotomy. And in another of the cases (under my care in Guy's Hospital in January 1862), the patient had apparently made his last gasp, but after tracheotomy had been performed, was brought back, as it were, to life, by long-continued artificial respiration. He lived for fourteen days, and then died of broncho-pneumonia. Comminuted fractures of the cricoid and thyroid cartilages were found, with laceration of the mucous membrane.

5. *Rupture of the trachea.*—Partial or complete rupture of the trachea without corresponding laceration of the soft parts is occasionally, but very rarely, caused by external violence. Such an injury is generally fatal from obstruction to respiration.

Dr. Berger* relates the case of a man who was kicked by a horse just below the lower jaw. There was hardly any wound, but the neck became much swollen. The breathing was greatly embarrassed, and general emphysema came on. The patient died in an hour and a half. The trachea was found almost completely separated from the larynx, about a third of the connexion only remained. Several rings of the trachea were torn through. The larynx itself was uninjured. The lungs were much loaded with blood, and the trachea was full of coagula.

In the following case, which occurred in the neighbourhood of Glasgow, the trachea was totally divided. A boy, driving the gin of a coal-pit, placed himself on the end of the lever. On stretching out his head to look at something, his throat came in contact with a post. Such was the force with which he was going round, that the trachea was ruptured across. He survived for several days, but in great agony.†

Mr. Long,‡ of the Liverpool Infirmary, has put on record a good instance of recovery after rupture of the trachea. This case also serves to show the treatment that may be employed under similar circumstances.

A railway labourer, aged twenty, while connecting two railway carriages, was caught round the neck by the coupling irons. When brought to the

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* *Med. Times and Gazette,* 1856, p. 650; from the Berlin *Medicin. Zeitung,* No. 33.

† Beck's *Medical Jurisprudence,* 7th ed. p. 718.

‡ *Med. Times and Gazette,* July 26, 1856, and Oct. 15, 1859.

Infirmary, there was some abrasion of the skin of the neck, a little swelling, and slight emphysema. The voice was subdued. In the evening there was some difficulty of breathing, and considerable distension and pain in the neck. Similar symptoms came on at intervals during the five days following the accident, and became at last so urgent that an incision was made in the median line of the neck. The finger was introduced into a mass of clotted blood, but the trachea could not be found. On subsequently turning out the blood, a bubble or two of air escaped from the lower part of the incision just above the sternum. On further examination, it was found that the trachea had been completely divided, and that the lower portion, from which the bubbles of air came, had been pushed on one side. There was an interval of an inch or more between the separated portions of the air tube. A long canula was introduced by Dr. Halford (then House Surgeon), and the blood which clogged the trachea was repeatedly sucked out. The patient became more and more relieved. The head was bent forwards so as to diminish the extent of the gap. Nine days after the accident the tracheal tube was removed, and a double piece of gauze placed over the opening. The wound entirely closed in about a month. When Mr. Long examined the patient about six months after the accident, he observed a depression to exist 'in the throat, just above the sternum, capable of holding a walnut;' this was increased doubly in depth and width during each inspiration. A fragment of trachea could be detected attached to the lower part of the larynx; below this nothing was felt like tracheal rings, but merely a fibrous tissue; his voice was hoarse, like that of a person suffering from the commencement of a cold; and when he breathed quickly and deeply, the sound produced was that of air passing through a narrow tube. 'I presume, therefore,' says Mr. Long, 'that a fibrous tube has been developed in the space existing between the upper and lower ends of the divided trachea.'

Injury of the Larynx from the Inhalation of Flame.

Mr. Ryland appears to have been the first to direct attention to the effects produced on the larynx by the inhalation of flame, or of intensely heated air. In his 'Treatise on the Diseases and Injuries of the Larynx and Trachea,' he describes the post-mortem appearances observed in four cases; and remarks 'that the symptoms during life, were those of severe bronchitis, without any of that peculiar dyspnœa that results from an obstructed condition of the laryngeal aperture.' Injuries of this kind are probably more frequent than is commonly supposed. It is easy to understand how they may occur. When the clothes are blazing round, or when the sufferer is in the midst of a burning house, any inspiratory effort may draw some portion of flame or hot air at any rate as far as the glottis. The intense inflammation of the respiratory tract, which sometimes immediately follows an extensive burn, may be thus explained. Such inflammation must, however, be distinguished from the low form which so frequently supervenes at a later period.*

Out of twelve cases of inflammation of the larynx from inhalation of flame, under observation at St. George's Hospital, in nine the neck and face were severely burnt; in three the superficial burn was confined to the lower limbs and lower part of the trunk. In a few of these cases there was difficulty of respiration almost from the time of the injury; in others, symptoms of dyspnœa came on a few hours afterwards, or on the first or second day following the injury. Death occurred in the majority of cases on the first or second day, but in two cases as late as the eighth or ninth day. In those cases in which the burn had extensively injured the face and neck, symptoms of dyspnœa were noted very early. In the two cases in which death did not take place until a much later period, the burn affected only the lower limbs and lower part of the trunk; and difficulty of breathing did not come on until the second day after the injury, and at first was only slight. In both of these cases the affected parts were extensively and deeply injured; but it is proper to add that the patients were at a period of life when the constitutional powers are most capable of supporting the shock of such an injury. The patients in the other cases were children or aged persons.

The post-mortem appearances are as follows:—The mucous membrane of the mouth is of a dark livid colour, or inflamed and œdematous. The tongue is occasionally much injected. The mucous lining of the fauces, and sometimes that of the pharynx, is of a bright scarlet hue. The vascularity ceases, as a rule, at the junction of the pharynx and œsophagus. In one case, however, the redness was found to extend about an inch along the œsophagus; and in another, the whole length of the tube was of a dark livid colour. The mucous membrane of the epiglottis, and of the aryteno-epiglottidean folds, is of a bright scarlet hue, and the submucous cellular tissue œdematous. The mucous lining of the larynx and trachea is inflamed, and shreds of lymph are occasionally seen on its surface. The lining membrane of the bronchi is often inflamed, and the tubes are loaded with thick yellow mucus. The pleuræ are rarely affected. The lungs, in most cases, are either congested or sprinkled with patches of a vivid red colour, or in more advanced stages of inflammation.

In very extensive burns respiration is commonly much accelerated; and consequently, the early detection of laryngeal inflammation may sometimes be difficult.

The treatment should be antiphlogistic. Calomel and antimony may be administered with advantage, in small but frequently repeated doses, as soon as croupy breathing indicates the existence of inflammation of the larynx. It must be borne in mind, however, that in the low forms of pulmonary inflammation, which so frequently follow severe burns, the very opposite treatment is required.

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* *Treatise on the Diseases and Injuries of the Larynx and Trachea,* by Frederick Ryland, 1837, p. 274.

Scald of the Larynx.

Dr. Marshall Hall* appears to have been the first to publish a full account of this form of injury.

The accident happens usually to young children, and generally occurs during attempts to drink, by mistake, boiling water from the spout of a tea kettle or other culinary vessel. The effects of such attempts, except in a few rare instances, are not, as might be supposed, to cause injury and inflammation of the œsophagus and stomach. Fluid of boiling temperature taken into the mouth is rarely, if ever, swallowed. It is arrested in its onward course by spasmodic action of the muscles of the pharynx, and efforts to expel it are almost instantaneously made. During these efforts it is possible that some of the fluid may accidentally enter the upper orifice of the larynx. It is more probable, however, that the result is produced in the following manner. The moment the hot water touches the interior of the mouth, acute pain is felt, and the child is instantly incited to scream. Preparatory to the scream, a sudden inspiratory effort is involuntarily but necessarily made. By this effort some of the boiling fluid, or hot steam from it, may be drawn into or towards the larynx. And thus the upper part of this portion of the air tube may be scalded, together with the interior of the mouth and fauces. In many cases, however, the larynx itself is not actually scalded, but becomes speedily implicated by extension of inflammation and œdema from the fauces. In other cases spasm of the glottis may be excited, and give rise to the belief that the larynx has been directly implicated in the injury.

Immediately upon the receipt of the injury the sufferer screams violently, and, by instinctively applying both hands to the mouth, indicates the part injured. On examining the mouth, the whole inner surface is found inflamed, swollen, and vesicated and the soft palate and fauces present similar appearances. This condition of the parts is attended by great pain, and difficulty in swallowing, or even total inability to do so. There is more or less hoarseness of the voice. The child becomes restless, and symptoms of inflammatory fever soon appear. Within two or three hours the respiration may become affected. Sometimes a delusive period of prolonged calm follows the injury, and after several hours, almost suddenly gives place to an access of alarming symptoms. Inspiration becomes difficult, and is accompanied by a hoarse croupy sound, and aggravated by occasional attacks of spasm. The difficulty may increase gradually or very rapidly. In many cases the child suffers from frequent vomiting. Unless these symptoms are soon relieved, the face becomes livid, the extremities cold, the respirations more hurried and oppressed, the voice quite lost, and the child gradually sinks into a state of collapse ; or death takes place in a fit of suffocative spasm. In some cases the little patients recover from imminent danger within three or four days, or even earlier. In other cases death from suffocation speedily ensues ; or if this is prevented by the timely performance of laryngotomy, tracheal or pulmonary disease may prove fatal at a later period.

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* *Med.-Chir. Trans.* vol. xii.

After death indications of inflammation of the lining membranes of the cheeks, fauces, and tongue are found. These parts are swollen and corrugated ; and the mucous membrane is raised into blisters, or covered with whitish patches. There is redness and swelling of the pharynx, and in one case, related by Mr. Gillman,* 'the œsophagus to within a short distance of the cardiac orifice of the stomach presented the usual appearances of a scald.' The mucous membrane of the epiglottis, and the glosso-epiglottidean and aryteno-epiglottidean folds, are thickened, from effusion of lymph into the subjacent areolar tissue. Occasionally this occurs to such an extent as to close the upper orifice of the larynx ; but the œdema never extends below the true vocal cords. In case the patient has lived only a few hours, the mucous membrane below the rima may be quite healthy. In case, however, the patient has survived longer, the mucous membrane of the trachea and bronchi is, as a rule, highly inflamed, and occasionally covered by adventitious membrane similar to that produced in croup ; or the tubes may be loaded with thick viscid mucus. In such cases the lungs are usually congested, and some of the pulmonary tissue is in a state of hepatisation.

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* *Med.-Chir. Trans.* vol. xii. p. 9.

The symptoms and post-mortem appearances show that injuries of this kind may cause death by suffocation, either rapidly, from violent inflammation of the larynx, or more slowly, through extension of inflammation to the bronchi and lungs.

Treatment.—The most active antiphlogistic treatment must be employed. Leeches should be applied to the throat in the immediate vicinity of the larynx, the number being proportioned to the age and strength of the patient, and the urgency of the symptoms.

Counter irritation by blisters applied to the upper part of the chest may be of benefit in some cases.

Calomel may be administered in doses of two or three grains every hour, until the symptoms are relieved, or until indications of constitutional effects appear. The dose may then be diminished and given at less frequent intervals. The advantage derived from the use of calomel in these cases was first pointed out by Dr. Wallace of Dublin. It has recently been strongly urged by Mr. Croly* of Dublin and others. Numerous instances have occurred, in which the exhibition of this remedy has been followed by the most marked relief. It occasionally happens that the patient is unable to swallow: under such circumstances mercurial inunction may be employed. Indeed, Mr. Croly recommends inunction simultaneously with the administration of calomel. I have seen the best results follow the administration of antimony and aconite in small but very frequently repeated doses. One or two minims of the antimonial wine, with a quarter or half a minim of tincture of aconite, may be given at first every quarter of an hour; then every half hour; and subsequently at longer intervals, according to the effect produced.

If the symptoms are not relieved, and suffocation appears imminent, laryngotomy or tracheotomy must be performed. It is impossible to lay down any precise rules as to the conditions under which the operation may become necessary. It must be left to the judgment and discretion of the practitioner to decide, after having taken into consideration each point in the particular case before him. As a general rule, however, in the opinion of most surgeons of experience, it is desirable to delay the operation as long as possible. But the patient must be carefully watched; and the surgeon must be prepared to operate at any moment. It should be remembered that though the operation may relieve the patient from impending suffocation, it has comparatively little effect in subduing the inflammation set up by the injury. It affords rest, however, to the injured part; and saves it from being irritated by the passing breath.

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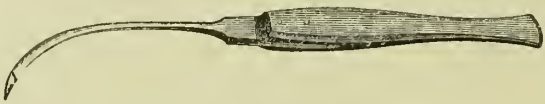
* *British Med. Journ.* June 16, 1866. On the same subject, see Sloane, *British Med. Journ.* January 14, 1866; Bevan, *Dublin Quart. Journ.* February 1860.

The statistical results of tracheotomy in cases of scalds and burns of the larynx, are certainly not encouraging. But it must be borne in mind that the accident is at best very dangerous, and it is only in the worst cases that the operation is performed. Out of 28 cases* of tracheotomy in scald of the larynx (of which I have notes) 23 terminated fatally.

Scarification of the inflamed and œdematous mucous membrane of the back of the fauces, and about the upper part of the larynx, often affords manifest relief, and never, if carefully performed, can be productive of mischief. The operation may be performed with comparative ease by means of a strong, sharp, curved 'needle-in-handle,' or a curved bistoury defended to within a sixth of an inch of its point by a strip of sticking-plaster; or, better still, by means of the instrument figured below, designed by Mr. Tudor, formerly of the Dreadnought, and by him named the epiglottome.

Fig. 63.



The Epiglottome.

The finger of the left hand must be introduced well into the back of the mouth or pharynx, and made use of to defend and guide the point of the instrument. Several punctures may be made into the swollen parts. In some cases it may be possible to use the laryngoscope with advantage.

INJURIES OF THE LARYNX FROM DRINKING THE CONCENTRATED ACIDS, AND OTHER CORROSIVE LIQUIDS.

The concentrated acids, and other irritant fluids, are sometimes swallowed with suicidal intent, and at other times are taken accidentally. If taken intentionally, the fluid may be swallowed without the slightest complaint of uneasiness or pain. Mr. Porter says:† 'I have known a young girl, after taking sul-

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[*] Collected from various publications; in Guy's Hospital; or elsewhere under my own observation.

[†] Op. cit. p. 178.

phuric acid, sit quietly and drink tea with some females, who were afterwards suspected of poisoning her, although the dose had been so powerful that she died in a few hours; and I am aware of a man who took a second glass of the same acid, because he thought the first was not sufficiently quick in dispatching him.' In cases of this kind the larynx is seldom injured. Notwithstanding the pain necessarily produced, and the highly irritating nature of the liquid, the determination to swallow it is so great that it passes over the epiglottis, along the œsophagus, and into the stomach, without producing any injury to the upper end of the air passage. But if the fluid is taken accidentally, the effect may be similar to that produced in cases in which boiling water is taken into the mouth. The presence of the irritating fluid excites such an amount of spasm of the muscles of the pharynx and larynx as entirely arrests its course along the gullet. At the same time instantaneous efforts at expulsion are made, and the fluid may be forcibly ejected through the nostrils and mouth. During these efforts it is possible that some of the fluid may enter the larynx. It is more probable, however, that the fluid is drawn in by a sudden inspiratory effort, excited in the manner suggested in the above account of scalds of the larynx, p. 467.

The post-mortem appearances are consequently liable to differ in these two classes of cases. In instances in which corrosive liquids have been swallowed intentionally, the lips are desiccated and charred, or corroded, and are covered with white patches, or discoloured in a manner varying with the nature of the liquid; the tongue is similarly affected, and swollen; the soft palate and fauces are highly vascular; the œsophagus is usually more or less affected throughout its whole extent, everywhere congested, and in places very dark in colour; the lining membrane of the stomach is often blackened, and sometimes disintegrated, portions of it lying flocculent and loose. On the other hand, in instances in which these fluids have been taken accidentally, the injuries are for the most part limited to the mouth, fauces, pharynx, and larynx. But sometimes the trachea and bronchial tubes are reached. Indeed, Dr. Gull * has recorded a remarkable case in which sulphuric acid passed into and partially destroyed both lungs.

The particular effects and appearances to which different

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* *Med. Gaz.* vol. xlv. p. 1,102.

corrosive liquids give rise when swallowed, and the manner in which they are liable to affect the air passages, are very fully described, and numerous examples are quoted, by Dr. Taylor, in his treatise on Medical Jurisprudence.*

In some cases it would appear that inflammation of the larynx, at least to such an extent as to impede respiration, never takes place.

Cases, however, occasionally happen in which very acute symptoms of laryngitis come on very soon after the accident. These symptoms may be the direct result of injury to the larynx itself, or they may be due to extension of inflammation from the injured fauces or pharynx.

If the liquid taken is of a volatile or fuming nature, as ammonia, or nitric, hydrochloric, or acetic acid, the fumes may be inhaled, and give rise to inflammation of the larynx and other parts of the respiratory tract. Many fatal cases of this kind are on record.†

Treatment.—The same treatment should be adopted as is applicable to laryngitis from other causes. Leeches and fomentations should be used externally, and calomel administered in small but frequently repeated doses. If the symptoms are not relieved by these means, and suffocation appears imminent, tracheotomy should be performed. In such a case the surgeon operates to rescue the patient from impending death; but the extensive mischief produced by the contact of the poison with the neighbouring parts, or more distant organs, generally leads to a fatal issue.

Three cases of this kind in which tracheotomy was performed have recently been under observation in Guy's Hospital. In one case the patient, who had taken strong acetic acid, recovered. In the other two, death resulted from the effects of the injury. In one of these, sulphuric acid had been taken. The parts about the glottis were so swollen as to cause complete closure. In the other case, carbolic acid had been taken. The bronchi were choked with brown thick mucus smelling strongly of the poison.

Foreign Bodies in the Air Passages.

Foreign bodies of the most diverse kinds occasionally enter the air passages, and imperil or more or less speedily destroy life. Among the foreign substances that have been most frequently found in the air passages, may be enumerated portions of food, plum and cherry stones, peas, beans of various kinds, acorns, nutshells, melon and pumpkin seeds, ears of grass, grains of corn, portions of bone, teeth artificial and natural, shells, buttons, button moulds, pieces of money, musket balls, shot, and pebbles. A great many other substances, animal, vegetable, and mineral, have been found in rare and exceptional instances: for example, puff-darts, worms, leeches; claws of crabs, &c. In one instance, the larynx of a goose was found; in another, a detached bronchial gland.

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* *Principles and Practice of Medical Jurisprudence,* by Alfred S. Taylor, M.D. 1865, p. 160 et seq.

† Case of Mr. Haywood, *Lancet,* April 1854, p. 430. Case of Mr. Stewart, *Chemical News,* March 1863, p. 132, &c.

Generally, only one foreign body enters at a time; but cases have occurred in which 'two, three, or even four foreign substances have entered the air tube either simultaneously or successively.'*

Some foreign substances (vegetable or animal), such as peas, beans, portions of meat, &c., when retained beyond a certain period, are liable to become enlarged by imbibition of moisture; and consequently they may occlude more closely the part of the tube in which they are lodged.† Any foreign substance may become coated with inspissated mucus or lymph after remaining long in the air passage. These facts are of practical importance, since they go to prove that the longer a foreign substance is retained, the greater danger there may be of increased obstruction to respiration.

Liquids, as drinks, medicines, blood, pus, &c., sometimes get into the air passages. As a general rule, however, they are speedily expelled, and surgical aid is not required. But it may happen that the most serious results may follow if, from any cause, expulsion cannot be quickly effected. In such case death from suffocation may ensue,‡ or inflammation may be set up. Attention has recently been directed to a class of cases in which suffocation has occurred during sleep, or during drunkenness, and in which, on examination, the air passages have been found filled with fluid material, similar to that contained in the stomach. In some such cases the lung tissue has been observed to have been more or less affected by the solvent action of the gastric juice. It has been suggested, in explanation, that vomiting or regurgitation from the stomach may have taken place during unconsciousness; and that, under such circumstances, vomited material may have been drawn by inspiration from the pharynx into the air passages. Cases of this kind are doubtless very rare, but it is possible they may be more frequent than is commonly supposed.*

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* A large number of interesting and curious cases have been collected together by Professor Gross of Philadelphia, and published, with practical comments, &c., in an elaborate *Treatise on Foreign Bodies in the Air Passages*; Phil. 1854.

† Gross. Op. cit. p. 37.

‡ See remarks on blood in the air passages in the chapter on Wounds of the Neck, p. 452.

Modes of entrance.—Foreign bodies, which enter the air passages, usually pass by way of the mouth; but this is not invariably the case (see p. 475).

As a rule, the foreign body is drawn in from the mouth by a strong, sudden, ill-timed or unguarded inspiratory act. Sometimes it may simply fall through the mouth into the larynx, as when a person is throwing up and catching a coin in the mouth.

The accident does not happen, as is popularly supposed, during the act of swallowing. But in exceptional instances it may do so; as for example, in cases of paralysis of the muscles of deglutition, and in cases of partial or complete destruction of the epiglottis. Under ordinary circumstances during the process of deglutition the larynx is elevated, and the epiglottis falls over and completely closes its upper aperture: the entrance of the smallest morsel of food is thus effectually prevented.

The accident most frequently happens to persons engaged in talking and laughing while their mouths are filled with food, or contain some foreign substance or other. Preparatory to the act of speaking or laughing, a deep inspiration is necessary: during this the epiglottis is raised; the upper orifice of the larynx is opened; and the margins of the glottis are widely separated. If under such circumstances, the mind is engaged by interesting conversation, or the attention is suddenly attracted, the vigilance of the muscles guarding the aperture of the larynx may not be excited; and any object contained in the mouth may be drawn by the current of inspired air into the larynx or trachea. Sometimes a blow, or unexpected slap on the back, or a sudden desire to sneeze, at once diverts the attention, and incites a strong inspiratory effort.

Many cases have occurred in which projectiles in blow-tubes, or peas or cherry stones in peashooters, have been drawn into the air passages by careless or unguarded inspirations.

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* For cases in illustration, see *L'Union médicale,* No. 91, 1868:—Case of a child, by Dr. J. Parrot. Also *Annales d'Hygiène,* 1869. p. 471.

But though the mode of introduction by inhalation from the mouth is the most common, there are various other ways by which in exceptional cases foreign bodies have been known to get into the air passages. And it may become a matter of some importance in the diagnosis of certain cases to be acquainted with some of these ways.

In some instances foreign bodies pass from the œsophagus and pharynx into the air passage.

A stout hearty labourer died suddenly whilst eating his Sunday's dinner. On examination, a piece of meat was found in the rima glottidis, and a quantity of masticated beef and cabbage in the trachea and bronchi. It seems probable that the man had filled his stomach to such an extent as to induce vomiting, and that in consequence of his endeavouring to inspire at the moment the food was being rejected, some of it had entered the air passage.*

Again, numerous instances are recorded, both by ancient and modern authors, in which lumbrici have made their way from the stomach into the pharynx, and thence into the larynx and trachea.† In some such cases death by suffocation has resulted. Instances have also occurred in which leeches, probably swallowed in drinking water, have passed from the pharynx into the air passage. M. Vital relates a case in which a living leech was removed by tracheotomy from the trachea of a soldier.‡

It occasionally happens that a communication between the œsophagus and trachea results from long standing ulcerative disease, as epithelioma, &c. In any such case, foreign bodies may pass through the opening, and get into the air passages. Such cases are not rare. I have seen several, and in some of them tracheotomy has been necessary. Again, foreign bodies may enter through artificial openings, as in wounds of the throat. And sometimes foreign bodies impacted in the œsophagus produce ulceration, and pass through into the trachea.§

A case, related by Mr. Edwards || of Wolverhampton, affords perhaps the most remarkable illustration on record of the manner in which a foreign body may get into the air passages, as well as of the extraordinary source from whence such body may be derived. A boy, æt. 8, playing with other boys about his own age, was offended or struck by one of them. He ran off to tell his mother.

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* Ryland, op. cit. p. 280.

† Aronssohn, *Arch. de Méd.* 1836, tom. x. p. 44.

‡ *Gazette médicale*, 1838, p. 139.

§ Bégin, *Journal hebdom.* quoted with other cases in *Diction. encyclopédique des Sci. méd.*, art. Larynx, pp. 705, 6.

|| *Med.-Chir. Trans.* vol. xxxvi.

Just as he got home, thirty yards distance, he seemed to be in a fit. He struggled violently; his head was thrown back; his countenance anxious, his face discoloured; and he said once or twice that he should die. He denied having swallowed anything. Tracheotomy was performed in about half an hour, and artificial respiration attempted, but without any beneficial effect. On dissection there was found fixed in the rima glottidis a body about an inch in length. This, on further examination, proved to be a bronchial gland, which had become detached, and had made its way by ulceration through the bronchus into the air passage. On slitting open the trachea, the ulcerated opening through which the gland had passed was found. Another remarkable instance of a foreign body getting into the windpipe without passing through the rima glottidis is mentioned by De La Martinière.* A child, nine or ten years of age, amusing himself with cracking a small whip, was suddenly seized with extreme difficulty of breathing, and soon exhibited all the symptoms of approaching suffocation. The surgeons who saw him did not suspect the existence of a foreign body impeding respiration. He was bled; the throat was examined, and an œsophageal bougie passed, without any discovery being made. The symptoms became more urgent, and De La Martinière saw him an hour after. On examining the neck externally, a small red spot was found immediately below the cricoid cartilage. Beneath this was felt, deeply, a little circumscribed ganglion, as large as a lentil. It was at once determined to cut on to this spot. On doing so an irregularity projecting a line in front of the trachea was felt. This proved to be due to the presence of a large copper pin, which was at once extracted. The pin was an inch and a quarter in length. It had been fixed in the end of the lash of the whip. The trachea had been pierced through from left to right. The child got well in a few days.

Situation and mobility.—The different situations which the foreign body, however introduced, may occupy, and the manner in which it may become moved from one situation to another, must now be considered. The size, shape, and weight of the body and the mode of introduction often, to a certain extent, determine the situation it occupies, and its degree of fixity.

1. The foreign body may be arrested in the larynx. It may become impacted in the superior aperture, or in the cavity, or in one of the ventricles of the larynx, or it may be lodged and firmly held in the chink of the glottis. Sometimes it may become fixed immediately below the glottis.

2. The foreign body may pass into the trachea, and occasionally, but very rarely, may be arrested there. Generally, however, it descends into one or other of the bronchi, and in the majority of instances into the right one. Instead of becoming fixed, the body may be moved up and down during respiration. Sometimes it may pass from the bronchus into the trachea, and

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* 'Observations sur un corps étranger,' &c., in *Mém. de l'Acad. de Chir.* vol. v. p. 521.

then into the other bronchus. Sometimes it may pass from the trachea up into the larynx, and there become impacted.

3. The foreign body may enter one of the second or third divisions of the bronchus, and there become firmly fixed.

4. At a later period the body, after having excited inflammation and ulceration, may find its way into the lung-substance, where it may become encysted, or may give rise to further mischief.

Out of twenty-one cases analysed by Professor Gross,* in which death took place without operation, and without expulsion of the foreign body, 'in four, the foreign substance was situated in the larynx; in one, partly in the trachea, partly in the larynx; in three, in the trachea; in eleven, in the right bronchial tube; in one, in the lung; in one, in the right pleural cavity.'

'Out of forty-two cases subjected to operation or general treatment, the extraneous substance was situated twice positively, and eleven times probably, in the right bronchial tube; four times certainly, and four times probably, in the left bronchial tube; seven times in the trachea, and fourteen in the larynx.' Out of fifteen cases under observation in Guy's Hospital during the last few years, in seven the foreign body was in the larynx; in five, in the trachea; in two, in the right bronchus; and in one, in the left bronchus. It would thus appear that the larynx and the right bronchial tube are the most frequent situations in which foreign substances are arrested. This conclusion, however, does not precisely coincide with that derived by M. Bourdillat † from the analysis of 166 cases. In eighty of these the foreign body was in the trachea; in thirty-five, in the larynx; in twenty-six, in the right bronchus; and in fifteen, in the left bronchus.

A foreign body which is too large to pass the glottis may remain impacted in the upper part of the larynx. A smaller, light, sharp pointed or angular body, as a husk of corn, a piece of nutshell, or a portion of applecore, may often stick in the larynx projecting into one or other ventricle or sacculus.

A foreign body of comparatively large size and irregular in shape, which has passed the larynx, may be impacted in the trachea, and produce more or less obstruction to respiration on both sides of the chest. The heavier the body, the less likely is it to move up and down during respiration. A small smooth body, as a pea or bean, especially if heavy, as a shot or small pebble, is more likely to descend into one of the bronchial tubes than a body less heavy, and more rugged or uneven.

The tendency of the foreign body to pass into the right bronchus rather than into the left, is mainly due to the fact, pointed out by Mr. Goodall of Dublin, that the septum at the subdivision of the trachea is somewhat to the left of the median line. The larger size of the right bronchus no doubt favours the tendency, though its more horizontal direction may have a somewhat opposite effect.

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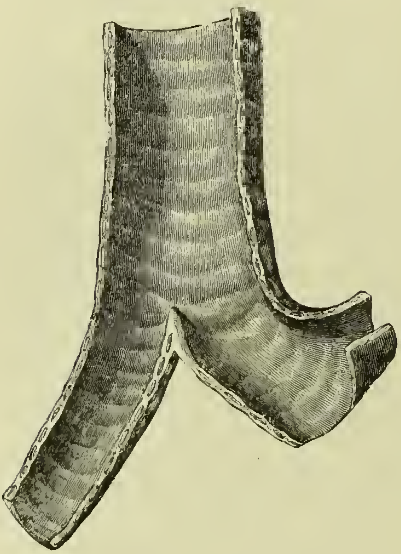
* Op. cit. p. 419 et seq.

† 'Des corps étrangers dans les voies aériennes.' M. Bourdillat, *Gazette médicale,* 1861, p. 135.

Fig. 64.



Bifurcation of Trachea, as seen from behind, the posterior wall removed; showing septum to the left of the median line. From a recent specimen.

Symptoms and diagnosis.—The symptoms which immediately attend the entrance of a foreign body into the air passage are violent spasmodic cough; difficulty of breathing and sense of suffocation; more or less lividity of countenance; and sometimes insensibility. After the first paroxysms have passed off, if the patient survives but the foreign body has not been expelled, the general symptoms are pain about the larynx, trachea or chest; recurrent spasmodic cough; more or less dyspnœa, and sense of oppression; alteration of the voice; expectoration; modified respiration, as evinced by auscultation and percussion; inability to lie in certain positions; and more or less impairment of the general health.

These symptoms vary according to circumstances, and sometimes none of them make their appearance for a very considerable period. Louis gives an instance in which, after the first few minutes, the patient did not experience a bad symptom for a year, at the end of which time he coughed up a cherry stone, followed by such copious expectoration, that he died exhausted in three days.

When a foreign substance is impacted in the superior aperture of the larynx, or wedged in the rima glottidis, the symptoms depend upon the amount of injury produced, and the extent to which respiration is impeded. Respiration may be impeded either by the mechanical obstruction, or by the spasm excited; consequently, the symptoms vary according to the size and nature of the extraneous body, and degree of irritation it causes. When the foreign body is large, such as a fragment of food, and firmly impacted, almost instant death takes place from suffocation. It occasionally happens that a foreign body, after having been lodged in the trachea for a variable period, is propelled, in a paroxysm of coughing, into the chink of the glottis, where it may become impacted, and speedily destroy life.

When the foreign substance is in the cavity of the larynx, and its size is insufficient to entirely prevent the passage of air, instant death does not always take place; and the symptoms then produced depend much upon the nature of the extraneous substance. If it is sharp, or angular, the symptoms are usually very severe. Pain is felt in the region of the larynx; there is a constant sense of suffocation, and great distress; violent and very frequent attacks of spasmodic cough occur; the respiration is croupy; and the voice is hoarse or altogether lost. In cases of this kind there is seldom any long-continued intermission of the symptoms; and this circumstance, together with the history of the case, the fixed pain in the larynx, and the absence of morbid sounds on auscultating the chest indicate the larynx as the seat of the extraneous substance. Unless relief is afforded by the expulsion of the foreign body during coughing, or by operation, death very soon ensues. If, however, the foreign body is small, and smooth, and round, no very severe symptoms may arise for some time.

When the foreign body is lodged in one of the ventricles of the larynx, the effects produced are similar to those noticed in the preceding cases; but they are less severe, and danger to life is less imminent.

A young man was admitted into the Hotel Dieu, who had suffered for six weeks from severe cough, accompanied by frequent attacks of impending suffocation. Great uneasiness was experienced in the region of the larynx. These symptoms were ascertained to have arisen from a button-mould having passed into the larynx. The trachea was opened, but though the button-mould was felt, it could not be removed by the finger. The cricoid cartilage was therefore divided: and the foreign body was then extracted from the left ventricle of the larynx.*

The patient may live a very long time when a foreign body occupies this situation.

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* Pelletan, *Clinique chirurgicale,* t. i. p. 8.

Desault * reports a case, in which a cherry stone was lodged in one of the ventricles of the larynx: the patient, who would not consent to an operation, died of laryngeal disease, but not until two years after the accident. Sir T. Watson † states that there is one instance on record in which a piece of gold was lodged for years in one of the ventricles of the larynx, without distressing consequences.

The foreign body occasionally passes through the chink of the glottis, and becomes fixed in the lower part of the larynx, or in the trachea, immediately below the cricoid cartilage.‡ In this case comparatively little distress is experienced, after the first symptoms have passed off. Pain and tenderness are felt at the spot corresponding to the position of the body. The voice may be unaffected; but a wheezing, whistling, or croupy sound is heard during inspiration and expiration: occasionally there is entire absence of cough. In one case the patient, a child, laughed, spoke, and ate, as if nothing had happened.

The foreign substance may pass beyond the larynx into the trachea. In such cases the symptoms that arise, after the immediate effects of the accident have subsided, vary with the size, weight, and figure of the extraneous substance, and also with its fixity or mobility.§ If the body is light, of small size, with no great irregularity of surface, as a cherry stone, or plum stone, it may constantly change its position, and thus produce a train of very characteristic symptoms. Paroxysms of cough occur, and are especially violent when the foreign body is driven up against the glottis. The cough is usually harsh, dry, and hard, and occasionally succeeded by a long and sonorous inspiration like hooping cough. During the paroxysms the face is purple, the cheeks are swollen, the eyes protruding, and a quantity of saliva flows from the patient's mouth. The cough is, as a rule, succeeded by intervals of comparative quiet, during which the patient suffers little inconvenience. This want of persistence in the symptoms is liable to mislead the patient's friends, and even his medical attendant. Sometimes the foreign substance, during its movements upwards and downwards, is felt by the patient to strike the walls of the trachea, especially during forced expiration.

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* *Œuvres chir.* t. ii. p. 258.

† *Lectures on the Practice of Physic,* 4th ed. vol. ii. p. 436.

‡ See cases recorded by Mr. Cæsar Hawkins in *Med.-Chir. Trans.* vol. xxiii. p. 99; and one by Mr. Bullock, *Med. Gazette,* vol. xviii. p. 952.

§ See a paper by Sir B. C. Brodie, Bart., *Med.-Chir. Trans.* vol. xxvi. p. 286. This paper contains the particulars of the celebrated case of Brunel.

If the foreign substance is heavy, it is less likely to be driven upwards towards the larynx in the act of coughing; consequently the inconvenience produced, and the immediate danger, are less than in a case in which the foreign substance is light and freely movable. The ultimate danger, however, is quite as great.

The situation of the foreign body is occasionally indicated by uneasiness or pain, referred to the lower part of the larynx, the front of the neck, or just behind the sterno-clavicular articulation; and this is more severe when the foreign body is rough and jagged. In addition to these symptoms, M. Louis noticed in one case well-marked emphysema on both sides of the neck, just above the clavicle.

If the foreign body is allowed to remain, the symptoms that arise vary greatly in different cases. Death may occur from spasm of the glottis, or from mechanical obstruction in case the body should be propelled upwards into the rima: or rupture of one of the cerebral blood vessels may be produced during coughing. At a later period the lungs may become congested and emphysematous; or bronchitis, pneumonia, or pleurisy, may supervene. These symptoms occur in some instances very early, in others at more remote periods.

When a foreign body enters one of the bronchi, the symptoms produced, and the extent to which respiration is obstructed, depend upon whether the substance is fixed or movable, and also upon its size, nature and precise position.

If the foreign body is impacted in one of the bronchi, the entrance of air into the corresponding lung is necessarily more or less impeded. In some instances the obstruction is complete. There is then entire loss of respiratory murmur on the corresponding side of the chest. In other instances the obstruction is only partial. The foreign body may not occupy the whole calibre of the bronchus, in which case the vesicular murmur generally is diminished. Or the body may become lodged in one of the primary or secondary divisions, and consequently, there may be entire absence of the murmur over a certain limited space. In almost all cases natural resonance on percussion is preserved. As a rule, the chest, during inspiration, rises less on the affected than on the sound side. The respiration in the unobstructed lung generally becomes puerile. Fixed pain referred to the upper part of the chest, when the substance is immovable, or constant pain, or sense of weight, on one side or the other, may occasionally serve, with other symptoms, to indicate the position of the foreign body. The voice may be hoarse: the respiration may be wheezing: cough, aggravated on deep inspiration, and accompanied by mucous or purulent expectoration may also occur. Inflammation of the lung, sooner or later, adds to these symptoms; and if the foreign body is not expelled or removed, the expectoration becomes more copious, and ultimately highly offensive, and of a dark colour; the cough becomes more troublesome, and aggravated by any exertion or change of position; the patient suffers from disturbed nights, daily paroxysms of fever, and night-sweats: general depression ensues, and death from exhaustion results.

In some rare instances a foreign body may ulcerate its way from one of the bronchi into the lung substance. In such cases the symptoms depend upon the amount of irritation and inflammation set up. Sometimes the body may become encysted, and for years produce little or no inconvenience. But sooner or later it is liable to become a centre of mischief: the neighbouring parts become inflamed; the new encysting material (if there be any) breaks down; suppuration takes place; and various symptoms, and physical signs more or less resembling those of pulmonary phthisis present themselves; and death usually but not invariably results from exhaustion.

Diagnosis.—To diagnose with certainty the presence of a foreign body in any part of the air passage is often a matter of very considerable difficulty, and requires the utmost care and vigilance on the part of the surgeon. Some of the symptoms above detailed may, in certain cases, be absent; none of them are absolutely pathognomonic; and similar symptoms may arise from various other causes.

Laryngoscopical examination affords the means, and the only means, by which in some cases a certain diagnosis can be made. If the foreign body can be seen all doubt is at an end. But in very many instances this is impracticable or impossible, at any rate during the earlier periods. If the foreign body is in the larynx, the symptoms are often so urgent as to admit of no delay, or so severe as to render the patient unmanageable. If the foreign body is in the trachea, there is very little probability of its being seen; and if in one of the bronchi, none at all. Laryngoscopical examination should always be attempted when practicable, and while the urgent symptoms are in abeyance. Several cases have already occurred in which, under such circumstances, foreign bodies have been recognised and removed.

Foreign bodies impacted in the pharynx or upper part of the œsophagus, by pressing upon the larynx, or by exciting spasm of the laryngeal muscles, may cause death by suffocation.* Such cases must be distinguished from those in which the foreign substances are in the air passages. The passage of a bougie may be all that is required in the former condition; in the latter this is useless, or may do mischief.

Foreign substances sometimes get into the air passages of persons who are eating while in a state of intoxication. In such case the symptoms produced are liable to be mistaken for those of an apoplectic seizure. Mr. Porter † has examined seven cases in which death occurred from suffocation in this way; and a similar instance is recorded by Dr. L. Beale.‡

Cases occasionally come under the notice of the surgeon in which foreign substances are suspected to be in the air passages, although the attendant symptoms actually depend upon laryngitis, œdema glottidis, croup, laryngismus, rabies, or spasm of the glottis connected with ulceration of the larynx or trachea, or upon aneurism of the aorta pressing on the trachea or bronchial tubes, or upon pressure of a tumour on the laryngeal nerves. Other cases occur in which foreign substances really exist in the trachea, although the symptoms are believed to be dependent upon an attack of croup, or other inflammatory affection of the air passages,§ or even to be due to tubercular phthisis.‖

As an instance of the former class of cases may be mentioned that of a boy, æt. 3, admitted into St. George's Hospital in the year 1851. A small button with which he had been playing was supposed to have slipped down his throat; he had been previously in good health, and continued so for three days after the supposed occurrence. Difficulty of breathing then came on at intervals, with convulsions, foaming at the mouth, lividity of the countenance, a croupy sound during inspiration, and partial loss of voice. Emetics had been used without relief; and calomel, with Dover's powder, was ordered, which produced vomiting: but no button was expelled. The symptoms continued. The larynx was examined by the finger, but no foreign body was felt. Subsequently laryngotomy was performed, and several explorations were made with various instruments, but no extraneous substance could be found. The dyspnœa and croupy sound continued at intervals; and on the following morning a sudden fit of spasm occurred, which ended fatally. No foreign substance was found in the air passage after death. There was a little lymph upon the mucous membrane of the glottis; the mucous membrane lining the trachea and bronchi was very vascular, and the bronchial tubes contained much muco-purulent fluid.

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* See below, on the Foreign Bodies in Pharynx and Œsophagus, pp. 515, 520. Also, Stokes, *On the Diagnosis and Treatment of Diseases of the Chest*, Dublin, 1827; Habicot, *Mém. de l'Acad. de Chirurgie*, t. xii. p. 243, ed. in 12mo; Desault, *Œuvres Chirurg.* t. ii. pp. 246, 248.

† *Dublin Medical Press*, Feb. 9, 1859.

‡ *Path. Trans.* 1851–52, p. 250.

§ Numerous cases illustrating the difficulty of diagnosis are quoted by Gross, op. cit. See also *Mém. Des Corps Etrangers dans les Voies Aeriennes*, Dr. Bertholle, Paris, 1866.

‖ Gross, op. cit. See also *Gaz. Méd.* 1868, p. 701, for a recent illustration of this error.

As an illustration of the latter class of cases in which a foreign substance may be present, but the attendant symptoms mistaken for those of croup, Mr. Henry Gray records the following case. 'I once saw a little boy suffering from such urgent dyspnœa that it was necessary to open the trachea. The symptoms came on, according to his mother's account, on the disappearance of a cherry stone, with which he had been playing; but they simulated those of croup so closely that no further attempt was made to search for a foreign body. The boy died; and, after death, I found the cherry stone in the trachea.' *

Again, a foreign substance may enter the air passage at the moment that a blow or other injury is received, or at the commencement of a fit. Under such circumstances the difficulty of breathing which follows is not unlikely to be attributed to the effects of the injury or fit, and the real cause may be altogether overlooked.

A child playing in the street was struck by the shaft of a jaunting car. The bystanders declared that the wheel passed over her breast. She so far recovered in a few minutes as to be able to walk home. But her breathing was croupy; she suffered from intermittent cough, and incessant restlessness. At the end of about thirty-eight hours she had a paroxysm of convulsive cough. She flung her head on the pillow, and was dead in an instant. On post-mortem examination a portion of an almond shell was found in the larynx, with its rough broken edge in the rima glottidis. No trace of injury to the thorax could be discovered. Mr. Porter † remarks, 'In this case, the existence of a foreign body in the larynx or trachea had never been suspected. Nor am I aware that any symptom observed could have warranted such a supposition. It was considered as difficult breathing resulting from injury of the neck or chest.'

Such cases as those to which allusion has thus been made, and very many more that might be quoted, serve to show that there

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* Former Edition of this Work. A somewhat analogous case is recorded by Dr. Conway Evans in the *Edin. Med. Journal*, 1860, p. 636. See Holmes, *Surgical Treatment of Children's Diseases*, 2nd edit. p. 295: also Limousin, quoted by Bertholle, op. cit. p. 79, for similar examples.

† Op. cit. p. 193.

may be very great difficulty in forming an accurate diagnosis.* Extreme care, therefore, is requisite on the part of the surgeon in every case in which the symptoms are such as may be due to the presence of a foreign body in the air passage. Inquiry should be made into the previous history of the patient, especially as to the existence of any chest or throat symptoms before the supposed accident. Inquiry should also be made as to the probable presence in the mouth of any foreign substance; and the size and shape of any such substance should be, if possible, ascertained.

Cases in which foreign bodies are in the air passages may be distinguished from those in which respiration is obstructed by foreign bodies in the pharynx or œsophagus, by the comparative facility with which deglutition is accomplished in the former cases, and the difficulty generally experienced in the latter. The differential diagnosis may be generally established by examination with the finger, or by passing a probang down the œsophagus. In any doubtful case the probang should be passed without hesitation. If the foreign body should be in the food passage, not only will the diagnosis be made, but relief may be at once afforded. And if the foreign body should prove to be in the air passage, no harm is likely to arise from the exploration of the gullet.

The symptoms due to the presence of a foreign body in the air passage may be distinguished from those of croup or laryngitis by the sudden severity with which they make their appearance, and the absence of all premonitory indications. In the former case, also, there is at first little or no pyrexia, and the difficulty of breathing is intermittent. Severe paroxysms come on at intervals, and then for a time subside. The dyspnœa is especially marked during expiration: the reverse of this is observed in laryngitis. At a later period, when inflammation is established, the ordinary symptoms of laryngitis of course present themselves; and in some cases even false membranes, similar to those of croup, may, as already stated, be formed.

Bronchitis, pneumonia, pleurisy, and phthisis may all arise in consequence of, or in association with, the retention of foreign bodies during prolonged periods. The exact diagnosis in such cases is generally a matter of extreme difficulty. Very numerous cases are on record in which mistakes have been made.*

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* Upon this point, see Holmes, op. cit. p. 205.

Results.—The results that may follow the entrance of foreign bodies into the air passages have been already indicated. They may, however, be recapitulated with a few additional observations.

1. The foreign body may be expelled through the glottis, either immediately after its entrance, during a fit of coughing, or at some subsequent period, with or without having produced serious structural lesions.

The period at which expulsion may take place varies greatly, as will be seen from the following summary of 124 cases, in each of which spontaneous expulsion took place, and recovery ensued :—

Period of Expulsion.	No. of Cases.
Immediately, or in less than 24 hours	5
In from 1 to 8 days	11
„ 8 to 30 days	16
„ 30 days to 1 year	64
„ 1 year to 17 years	28
	124

Professor Gross quotes a very remarkable case (not included in the above summary) in which a portion of bone is stated to have been expelled after having been retained during a period of sixty years. Recovery followed.†

2. Death may occur almost immediately after the entrance of the foreign body, from suffocation, or at a subsequent and very variable period from the same cause ; or fatal hæmorrhage may ensue, as in Rokitansky's ‡ case, in which a small dart, drawn into the trachea, was forced into the innominate artery during a fit of coughing. In some cases in which the foreign bodies have been expelled, death from exhaustion or from some other cause has nevertheless resulted.

3. Various structural lesions of the most serious and often fatal character may be produced. For example, inflammation and œdema, or ulceration of the mucous membrane of the

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* See pp. 483–4. Also, Bertholle, op. cit. p. 84 et seq ; Bourdillat, 'Des Corps Etrangers dans les Voies Aeriennes,' *Gaz. Méd.* 1868, pp. 96, 121, 122. This article, continued through several numbers of the *Gaz. Méd.*, contains much information, and analyses of a great number of cases.

† Gross, op. cit. p. 172, quoted from *New York Journal of Medicine*, vol. vi. . 23.

‡ *Pathological Anatomy*, vol. iv. p. 37 (translated by Day for the Sydenham Society.)

larynx may be set up if the body is retained in the upper part of the windpipe; or if it has descended lower, inflammation of the lung-tissues, followed by consolidation, or suppuration, ulceration, or gangrene, may be caused. Sometimes the lung substance is traversed, and the pleura reached. In such cases empyema occurs.

A good illustration is afforded by the case recorded by Mr. Carpenter * in which a set of four false teeth, made of one piece of ivory, had been drawn into the air passage. Thirteen years afterwards the patient died after an attack of acute pleurisy. The right pleural cavity contained five pints of sero-purulent fluid, and in it were found the artificial teeth. A fistulous opening was observed on the surface of the lung, through which it was supposed the teeth had passed.

In some cases pulmonary emphysema results. In others the foreign body seems to serve as a nucleus, around which tuberculous deposit may take place.

4. In some rare instances foreign bodies, known to have entered the air passages, have been discharged, long afterwards, through abscesses or fistulous openings in the thoracic parietes.

5. Results more or less successful may follow surgical interference; or death may ensue, even though the foreign bodies have been removed.

As a general conclusion to this part of the subject, it may be definitely and decidedly asserted that life is in peril so long as a foreign body of appreciable size is retained in any part of the respiratory tract. At the same time, it is very uncertain at what period danger may become imminent, and in what way it may arise.

If this be true, it is obvious that the surgeon should lose no time in adopting such measures as may secure the safety of the patient, and aid the removal or expulsion of the foreign body.

The following carefully compiled summary of 554 cases must be taken for what it is worth, but it certainly seems to furnish a strong argument in favour of operative measures. It should be premised that no case is included in which death or expulsion immediately followed the accident.

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* *Guy's Hospital Reports,* 1st Series, vol. vii. p. 353.

RESULTS OF CASES OF FOREIGN BODIES IN THE AIR PASSAGES.

1. *Cases in which no operation was performed:—*	Total No. of Cases.	Recoveries.	Deaths.
RESULT.			
Death without expulsion of foreign body .	95	—	95
Spontaneous expulsion of foreign body .	164	149	15
Expulsion after emetics (recorded as useless in 46 cases)	5	5	—
Discharge at late period through thoracic abscess	7	2	5
Total of cases not operated upon . . .	271	156	115
2. *Cases in which operative measures were adopted:—*			
OPERATION.			
Laryngotomy, followed by expulsion . .	14	13	1
,, not followed by expulsion .	3	—	3
Tracheotomy	231	170	61
Laryngo-tracheotomy	20	15	5
Direct extraction	3	3	—
Inversion of body and succussion . .	12	12	—
Total of cases operated upon	283	213	70
Total number of cases, operated upon, or not .	554	369	185

It would thus appear that in the cases above summarised in which no operation was performed, death resulted in about 42·5 per cent.; and recovery in about 57·5 per cent. On the other hand, in the cases in which operative measures were resorted to, death resulted in about 24·8 per cent.; and recovery in 75·2 per cent. The general result, therefore, is greatly in favour of operative measures.

Treatment.—When a foreign body is known to be retained in some part or other of the air passage, the promptest treatment is demanded. The surgeon should not trust to the unaided efforts of nature to expel the extraneous substance, nor should he for an instant leave the patient unwatched until safety is assured. Temporising measures should never be persisted in when once the means of affording effectual relief are at hand. Emetics, sternutatories, and such like 'remedies' should not be administered. They are almost certain to increase the distress of the patient, and they are not likely to be productive of any good result.

If the circumstances of the case permit, attempts may be made to detect the foreign body, by aid of the laryngoscope, and to remove it by direct extraction.* In very many instances, however, in which the foreign body is in the larynx, the symptoms are so urgent that no time is to be lost. It is necessary, therefore, to defer the laryngoscopical examination until the safety of the patient has been ensured by opening the windpipe.

Inversion and succussion of the body of the patient have proved successful in some few cases: but in many more, this method has been tried in vain ; † and, as in the case of Brunel, it has frequently caused much distress. ‡ It cannot be considered as altogether free from risk, and should not be attempted unless the surgeon is prepared to open the windpipe at once in case of need. When the patient is inverted, the foreign body may fall from the trachea into the larynx, and there become arrested. In such case occlusion of the glottis and instant suffocation may ensue.

As a general rule, the windpipe should be opened with as little delay as possible in every case in which a foreign body is certainly known to be retained in any part of the air passage. By this means the immediate safety of the patient is secured, and the subsequent expulsion or removal of the foreign body is aided. In some cases there is not a moment to lose; the windpipe must be opened at once. Sometimes the patient may cease to breathe before this is accomplished. The operation should nevertheless be completed, and artificial respiration instituted and perseveringly maintained. In other cases there is ample opportunity for the administration of chloroform, which should always be given if practicable ; and the surgeon may operate with deliberation. In other cases, again, the symptoms may be so slight that the surgeon may be inclined to hesitate before adopting such severe treatment as that recommended. But there is great danger in delay. An interval of calm constantly precedes the recurrence of urgent symptoms. Temporary freedom from distress must not be regarded as contra-indicating the operation, but rather as affording the best opportunity for its performance. If the surgeon hesitates to operate under favourable circumstances, he may be compelled to do so in the greatest haste and under the greatest difficulties. In such case his chance of success is comparatively small. Opening the windpipe cannot be considered in itself a dangerous operation, if performed with due deliberation and care. The risks associated with it depend rather upon the conditions which render it necessary, or upon the ill effects of the retention of the canula in the air tube. Such risks are proved by experience to be considerably less when the operation is performed on account of the presence of a foreign body, than they are when it is performed on any other account. The expulsion or extraction of the foreign body, if effected early, at once removes the great source of danger; and there is rarely any necessity for the prolonged retention of the canula, if even it has been found necessary to introduce it for a time.

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* See case by Gibb, *Lancet*, 1864, vol. i. p. 39.

† Gross, op. cit. p. 205. Numerous examples.

‡ *Med.-Chir. Trans.* vol. xxvi. p. 286.

The part of the windpipe which should be opened depends upon the position which the foreign body is believed to occupy; and also to a certain extent upon the age of the patient, and the size and character of the extraneous substance.

When the symptoms indicate that the foreign body is in the larynx, laryngotomy should be performed. First, because in such cases the symptoms are, as a rule, most urgent, and this operation is perhaps the most easily and most quickly performed; and, secondly, because an opening through the crico-thyroid membrane is near to the foreign body, and consequently is favourably situated for future proceedings. A large opening should be made at once. If the patient is very young, and the crico-thyroid space does not permit an opening of satisfactory extent, the incision may be carried downwards, and the operation of laryngo-tracheotomy accomplished. It frequently happens that the full access of air to the lungs, thus afforded, enables the patient to expel the foreign body at once, either through the glottis, or through the opening made. If expulsion should not immediately take place, the best plan is to introduce a canula and wait a while. In the course of a short time the spasmodically contracted muscles of the larynx may become relaxed; and the foreign body being thus set at liberty, may be expelled. The canula secures freedom of respiration; and by its pressure serves to arrest hæmorrhage, and to prevent the entrance of blood into the air passage. When the patient has recovered from the immediate effects of the operation, if the foreign body still remains unexpelled, attempts may be made to dislodge it by removing the canula and exploring the larynx by means of a probe or catheter. Great care is necessary in doing this.

A case came under my observation some time ago in which a probe was repeatedly passed through the larynx up into the mouth, and the finger was also passed down through the mouth into the larynx, but no foreign body was discovered. The child seemed free from all distress, and breathed well through the larynx. It was supposed that the foreign body had been dislodged and coughed up although it could not be found. In the course of a few hours symptoms of suffocation suddenly came on, and before assistance could be rendered the child was dead. On examination a piece of apple-core was found in the rima glottidis, sticking across from one ventricle of the larynx. Several similar cases have been recorded.

If the foreign body is small and smooth and flexible, it may easily escape detection by a probe. A larger instrument should be used. The upper end of an elastic catheter may be recommended. The small ivory cap, with its flat top and hole in the centre, renders this instrument well adapted for the purpose; but it must be used with care.

After laryngotomy has been performed, and while the patient is breathing freely and safely through the canula, laryngoscopical examination may be made under favourable circumstances. If the foreign body is seen, it may be extracted by forceps, such as are represented in Figs. 65 and 66.

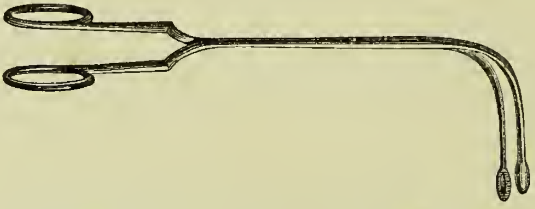
In some cases, Mackenzie's Laryngeal Forceps (Fig. 67) may be advantageously used. The stem of this instrument is so slender as not to obscure the view. The blades (*b*) are so arranged that they can be turned by the screw (*a*), so as to open in any direction. They are closed by pressure upon the trigger (*c*).

Forceps constructed after the method of Messrs. Robert et Collin (of Paris) are very suitable. This method of construction is illustrated by Fig. 78 on page 525.

If the foreign substance cannot be extracted by such means, inversion and succussion of the patient may be tried. There can be no risk in making the attempt after the larynx has been opened; and in some instances success has resulted. The celebrated case of Brunel, to which reference has already been made, affords an excellent illustration. This method is most likely to prove successful if the foreign body is smooth, rounded, and heavy, as a piece of money, a shot, or a bullet.

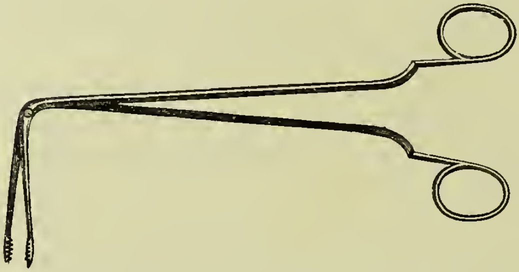
But it may happen that the foreign body still remains fixed in the larynx after full opportunity has been afforded for its expulsion, and fair trial has been given to the several modes of treatment already specified. In such case the surgeon should not hesitate to cut through the thyroid cartilage (*thyrotomy*). The interior of the larynx may be thus fully exposed, and the foreign body certainly found and removed. The incision through the thyroid cartilage should be carried perpendicularly upwards from the opening in the crico-thyroid membrane already made, and should be strictly in the middle line; it may also be extended downwards if needful, through the cricoid cartilage (*crico-thyrotomy.*) This operation may be performed perhaps somewhat more advantageously if the trachea rather than the larynx has previously been opened. In the former case the tracheotomy canula may be more readily retained during the

Fig. 65.



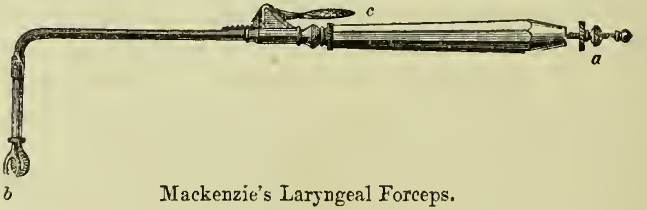
Laryngeal Forceps, the blades of which open laterally.

Fig. 66.



Laryngeal Forceps, the blades of which open antero-posteriorly.

Fig. 67.



Mackenzie's Laryngeal Forceps.

operation, and the entrance of blood into the air passage more easily prevented. Such at least has been my own experience. There is no difficulty in the performance of this operation, and there would not appear to be much risk involved. I find on record twelve successful cases, and not one in which death resulted. In some of the cases the voice has been more or less permanently affected, but in none of them to a serious extent. A similar operation has been repeatedly performed for the removal of morbid growths in the larynx, but with somewhat less uniform success.*

The period at which this operation should be performed must depend upon the circumstances and conditions of the particular case under consideration. As a general rule, the earlier it is done the better chance is there of complete success; the longer the foreign body is allowed to remain in the larynx, the more likely is it to set up inflammation, ulceration, and other structural lesions. I have performed this operation twice with the most successful results. In each case, however, there can be no doubt that if the operation had been performed much earlier than it was, the patient would have been spared considerable suffering and many risks.†

After the foreign body has been extracted, the edges of the incision through the thyroid cartilage may be brought together and secured by suture. It may be well to retain the laryngeal or tracheal canula for two or three days, or until all indications of laryngeal mischief have passed away.

When the symptoms indicate that the foreign body is in the trachea or one of the bronchi, tracheotomy should be performed. The opening made into the air tube should be of considerable extent, and as low down as practicable. Hilton ‡ recommends that a transversely valvular opening should be made. It has been suggested that a portion of the trachea should be cut completely out. Such a proceeding can never be necessary, and if adopted is not unlikely to be followed by serious consequences at a later period. The edges of the opening, whether simply longitudinal or valvular, should be held well apart by means of blunt hooks, or bent wires, or dressing forceps or some such dilator as that represented in Fig. 68. Or silk or wire ligatures may be passed through each edge of the wound and tied behind the neck of the patient. In many cases the foreign body is immediately expelled through the opening, and sometimes with very considerable force. If immediate expulsion does not take place, the effect of inversion and succussion may be tried. If this should fail, it is generally better to wait for a time, the patency of the opening in the trachea being secured. In some cases a canula may be introduced with advantage, and the patient allowed to recover thoroughly from the immediate effects of the operation. It cannot be too constantly borne in mind that in a large proportion of the cases that have done well, expulsion has not been effected until some time after the operation.* The surgeon therefore should neither feel disappointment, nor regret what he has done, even though the foreign body should not be speedily ejected, and the first attempts at removal should utterly fail.

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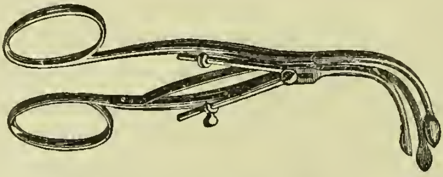
* Upon this subject, see an excellent monograph by Dr. Charles Planchon, *De Laryngotomie*, Paris, 1869. Also Durham, 'Cases of Operation on the Larynx,' *Guy's Hospital Reports*, 3rd Series, vol. xii. p. 540. Also Holmes, op. cit. 298, 311.

† Op. supra cit. pp. 544–5.

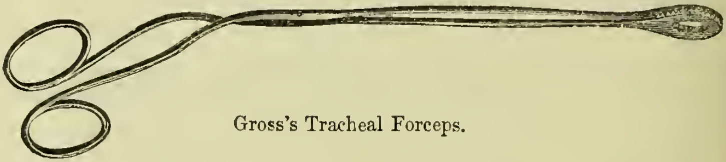
‡ See *Medical Times and Gazette*, 1867, p. 507.

Fig. 68.



Laborde's three-bladed dilating Forceps, as modified by Luer, and improved by Mayer and Meltzer.

Fig. 69.



Gross's Tracheal Forceps.

If the foreign body is still retained after full opportunity for expulsion has been afforded, attempts may be made to detect and remove it by means of properly curved forceps, introduced through the opening, and directed upwards or downwards according to circumstances.

The forceps of Professor Gross (Fig. 69) are well adapted for such a purpose: they are long and slender, and made of German silver, so that they can be bent to any degree, and in almost any direction that may be requisite. In some cases snares made of looped wire have been advantageously used. The introduction of any instrument into the trachea, or either of the bronchi, usually excites violent convulsive cough, with heaving of the chest and lividity of the face. The violent cough excited sometimes leads to the expulsion of the foreign body, or drives it between the blades of the forceps.

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* See Table, page 496.

If the foreign body is comparatively large, and is impacted in the upper part of the trachea, it is better to introduce a canula into the tracheal wound, and to wait until all spasm has had time to subside, and the parts are in a less irritated condition. If the foreign body is comparatively small and is situated in the lower part of the trachea, or has become impacted in one of the bronchi, it is better to lose no time in attempting to extract it by means of the forceps. Some substances, such as peas, beans, &c., may swell by absorption of moisture, and thus become more firmly impacted.* And others, as pebbles, shot, &c., by reason of their weight and hardness, may soon find their way on into one of the second or third bronchial divisions, and thus get hopelessly beyond reach.

The following summary of 167 cases in which tracheotomy was performed on account of the presence of foreign bodies in the air passages, may serve to indicate to a certain extent the general results that have hitherto attended the operation in such cases. The careful consideration of individual cases supplies still stronger arguments in favour of the operation, and goes to show that in most of the fatal cases death was due in no respect to the operation, but to delay in its performance, or to some failure or deficiency in the measures subsequently adopted.

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* See in illustration a case by Mr. Bryant, *Guy's Hospital Reports*, 3rd Series, vol. vi. p. 14.

Results of Tracheotomy on account of Foreign Bodies in the Air Passages.

1. *Cases in which recovery took place:—*	No. of cases.	Totals.	Totals.
Mode and Period of Expulsion or Removal.			
Spontaneous expulsion through the tracheal opening:			
a. Immediately after the operation .	39		
b. Within 24 hours	13		
c. At some subsequent period . .	10		
Total of cases of expulsion through tracheal opening		62	
Spontaneous expulsion through the mouth:			
a. Immediately after the operation .	13		
b. At some subsequent period . .	16		
Total of cases of expulsion through mouth .		29	
Removal by forceps, &c.:			
a. Immediately after the operation .	31		
b. At some subsequent period . .	8		
Total of cases of removal by forceps, &c. .		39	
Total number of cases in which recovery took place			130
2. *Cases in which death occurred:—*			
Retention, Expulsion, or Removal of Foreign Body.			
Retention until death	32	32	
Expulsion:			
a. Through the mouth, immediately after the operation *	1		
b. Through the opening, immediately † .	2		
Removal by forceps ‡	2		
Total cases of expulsion or removal . .		5	
Total of cases in which death occurred . .			37
Total numbers of cases analysed . . .	167	167	167

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* Death seven days after from broncho-pneumonia.

† Death in one case forty hours after operation, from convulsions; in the other, eight months afterwards, from pulmonary disease.

‡ In one case the patient did not rally: in the other, death occurred fifty-three hours afterwards, from blood getting into the trachea.

BRONCHOTOMY.

Under the general term *bronchotomy*, are included the several operations named respectively, laryngotomy, laryngo-tracheotomy, and tracheotomy. In each of these an opening is made into the windpipe, either to afford relief in case of obstructed respiration, or to facilitate the expulsion or extraction of a foreign body, or the removal of a morbid growth. Each operation has its own peculiar merits and advantages, difficulties and dangers, and shares others which are more or less common to all three.

In deciding which operation to perform, the surgeon must be guided in every case by the particular conditions which render the operation necessary, and also by the age and development of the patient. Laryngotomy is by far the easiest operation to perform, and its execution is attended by least risk; but it is not so generally applicable as the others, and it may involve subsequent as well as immediate damage to the vocal apparatus. Laryngo-tracheotomy is easy in execution, and not accompanied by any immediate source of danger; but it is liable to be followed by more or less permanent impairment of the voice, from the injury necessarily inflicted on the cricoid cartilage and parts therewith connected. Tracheotomy is comparatively difficult to perform, and during its performance dangers may have to be encountered greater and more numerous than those met with in either of the other operations; but it is by far the most generally applicable, and when once safely accomplished, is least likely, perhaps, to be followed by permanent ill effects.* But, as before said, the operation to be performed must be decided in each case by the conditions which render such an operation necessary, and the particular collateral circumstances. That which would be the worst operation in one case, may be clearly indicated, nay, absolutely demanded, in another.

Whichever operation may be selected, chloroform should always be administered when practicable. In a very large majority of cases it renders respiration easier by allaying spasm: it thus increases the safety of the patient, and relieves the surgeon from the demand which might otherwise arise for dangerous haste in the accomplishment of the operation.

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* On the comparative merits of these operations, especially in childhood, see the chapter on Tracheotomy in Holmes's *Surgical Treatment of Children's Diseases*, 2nd edit., p. 312 et seq. Also Mr. Marsh's article on Tracheotomy, *St. Bartholomew's Hospital Reports*, vol. iii. p. 337, 338.

In cases, however, in which suffocation is imminent from sudden obstruction the administration of chloroform is inadmissible. And it is unnecessary if the patient is already almost or entirely insensible from slow asphyxiation.

Again, whichever operation is to be performed, the patient, under the influence of chloroform or not, must be securely held in proper position before the knife is used. This is especially requisite if the opening is to be made into the trachea.

The patient should lie upon the back. A good firm pillow should be placed under the shoulders and upper part of the chest. The head must not be supported, nor propped forwards by any pillow, but must be thrown well back, and kept perfectly straight until the operation is completed. The chin must be elevated. The shoulders should be drawn downwards. This may be effected in the adult by traction upon the upper extremities; but in the child it is better to make use of a shawl or towel, arranged behind the shoulders, and carried on each side over the acromion and upper extremity, then crossed in front, and finally securely fastened behind and below. A small firm pad should be placed under the neck in such a way as to maintain or increase, as far as practicable, the anterior convexity of the cervical spine, and thus to throw the windpipe forward. By such means, future proceedings are greatly facilitated. When the patient is in the position described, it is comparatively easy to recognise by the touch the several parts which serve as guides to the surgeon in the operations under discussion. These parts are the thyroid cartilage, the crico-thyroid membrane, the cricoid cartilage, the upper part of the trachea, and the isthmus of the thyroid body. The precise situation of each of these should always be distinctly made out, if possible, before the knife is used. But it is often very difficult to do so, especially in the case of a young, short-necked, fat child. It has happened that the opening has been made through the thyro-hyoid membrane or through the thyroid cartilage instead of at the spot intended.* In the adult subject it is generally easy enough to make out the several parts mentioned, with the exception sometimes of the thyroid isthmus, the position of which, however, can be readily estimated if the cricoid cartilage is distinctly felt. The notch in the upper border of the thyroid cartilage may serve to indicate the middle line of this structure when its median ridge is not recognisable. The middle points of the lower jaw, the thyroid cartilage, and the upper border of the first piece of the sternum, give the line in which, in all of these operations, the incisions are to be made, and from which they should never deviate.

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* Marsh, op. cit. p. 349.

Laryngotomy.—In this operation the opening into the windpipe is made through the crico-thyroid membrane. The operation is simple, easy, and free from risk. It is performed as follows.

Chloroform having been administered or not, the patient is put into proper position, and the precise situation of the crico-thyroid space is ascertained. The larynx is then steadied between the fingers and thumb of the left hand of the operator, and the skin to be incised is at the same time rendered moderately tense. A perpendicular incision, an inch or more in length, is next made in the middle line through the integuments over the lower half of the thyroid cartilage, the crico-thyroid space, and the cricoid cartilage. The fascia between the two sterno-hyoid muscles and the areolar tissue are then divided, and the crico-thyroid membrane is exposed. The knife is then passed at once through this membrane, and the mucous membrane which lines it, into the larynx. Care must be taken to penetrate the mucous membrane effectually. When this is done, air, blood, and mucus are immediately and forcibly expelled in such a manner as removes all doubt.

The opening may be enlarged transversely to the extent necessary or desirable. During the course of the operation the edges of the wound may be held apart by retractors, and bleeding vessels may be secured. The only vessels at all likely to give rise to troublesome hæmorrhage are the crico-thyroid arteries (branches of the superior thyroid), which anastomose over the cricot-hyroid membrane, and which are very liable to be wounded. Cases are recorded in which serious and even fatal hæmorrhage has occurred from these vessels.* As a general rule, however, they are easily secured, if needful. by ligature or torsion. Unless the symptoms are very urgent, it is desirable to arrest all hæmorrhage before opening the windpipe. When an opening of sufficient extent is made, the canula is introduced. There is rarely any difficulty in doing this, if a blunt pilot trocar is used. But care must be taken to ascertain that the canula is actually in the air passage. Cases have occurred in which the canula has been passed down into the loose connective tissue in front of the windpipe instead of into the cavity of the larynx. Mr. Gray* refers to an instance in which the canula was pushed down between the crico-thyroid membrane and mucous membrane, the latter not having been penetrated at all. The forcible ejection of air, blood, mucus, &c., *through* the canula (not by the side of it) unmistakeably indicates that it has been properly introduced. The canula may be secured in position by means of soft tapes † passed round the neck, and tied. Or the elastic band, furnished with hooks, especially designed for this purpose, may be used. The tapes should always be attached to the canula previous to its introduction. The canula should be of uniform calibre throughout, and furnished with an inner tube. It should be oval (not circular) in section, and curved on the flat. Most laryngotomy canulas are made unnecessarily long.

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* Sir W. Fergusson mentions a case.

Laryngotomy is not applicable in early childhood, on account of the very limited dimensions of the crico-thyroid space at that period of life. It cannot be recommended in cases of acute or extensive disease or injuries of the larynx; nor is it likely to be of much service if a foreign body is in the trachea or bronchus. On the other hand, it is generally applicable in the adult subject, especially in the male. And it is probably the best operation to adopt in cases in which foreign bodies are impacted in the larynx, in cases of limited chronic disease, or contractions about the upper part of the larynx, such as often result from syphilitic ulceration, &c; and in cases in which respiration is impeded by polypoid or warty growths, and in which it is deemed right to open the windpipe before removing the growths.

2. *Laryngo-tracheotomy.*—In this operation the crico-thyroid membrane, the cricoid cartilage, the crico-tracheal membrane, and the first ring or two of the trachea, are divided. The general method of proceeding is similar to that practised in laryngotomy, but the first incisions must be somewhat longer; and in opening the windpipe the edge of the knife should be directed from below upwards, so as to avoid wounding the

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* See First Edition of this Work, vol. ii. p. 311.

† What is known to ladies as French braid is best.

isthmus of the thyroid body. This structure is comparatively large and vascular in early childhood, and if wounded is liable to bleed freely.

Laryngo-tracheotomy may be advantageously practised if, on account of the age of the patient, the crico-thyroid space is too small to admit an opening of sufficient size, and if, at the same time, the surgeon fears to open the windpipe lower down. This operation should not be performed in the case of an adult, because of the damage necessarily done to the vocal apparatus. When the cricoid cartilage has lost its early elasticity, the divided edges must be forcibly kept asunder, or a portion of the cartilage must be cut out. Either proceeding is likely to result in more or less permanent impairment of the voice, or aphonia. Necrosis of the cartilage also is liable to occur. Two fatal cases of the kind have come under my observation.

3. *Tracheotomy.*—In this operation the opening is made into the trachea either above, through, or below the thyroid isthmus. The operation above the thyroid isthmus differs in no important respect in its method of performance from laryngo-tracheotomy, except that the opening in the windpipe is limited above by the cricoid cartilage, and it may be requisite to draw the thyroid body downwards. In childhood, this operation does not afford sufficient room for the introduction of the canula, and in the adult the operation below the isthmus is generally preferable. The operation through the thyroid isthmus cannot be recommended. It involves putting two ligatures round the isthmus, and dividing this structure between them. Before this can be satisfactorily accomplished, considerable venous and even arterial hæmorrhage are likely to occur, and, until arrested, to cause much embarrassment.

The operation below the thyroid isthmus is that which is ordinarily understood by the general designation, tracheotomy. The advantages, as compared with the risks and difficulties of opening the trachea in this situation, are greater than those afforded by making the opening higher up. As a general rule, therefore, this operation is to be preferred. The dangers and difficulties that may be encountered are unquestionably great, especially in the case of a young fat child; but they are not by any means so formidable as is sometimes supposed, and, for the most part, may be certainly avoided by care and skill on the part of the surgeon.

The operation may be performed either by a process of slow and careful dissection, or by a more rapid but probably equally safe method. The first method is practised as follows:—

The patient, under chloroform or not, is put into the position already described. The facility with which the operation may be completed greatly depends upon the maintenance of this position throughout. The surgeon stands on the right of the patient. A careful preliminary examination of the parts is made, and the spot selected at which the trachea is to be opened. An incision is then made exactly in the middle line, extending from just above the cricoid cartilage nearly as low as the sternum. In the case of a short-necked fat patient it is very desirable to make the first incision long enough. The subcutaneous fat and connective tissue being divided, the sterno-hyoid muscles are brought into view, lying in close proximity one to the other, but between them a faint median line may generally be recognised. The fascia along this line is divided, and the muscles are hooked apart. The dissection is then cautiously continued through the fascia and connective tissue still in front of the trachea. These structures are divided layer by layer, and held carefully aside, together with any veins that may be seen. The position of the trachea is from time to time sought with the finger, and the absence of any large abnormal vessel ascertained. The dissection is continued until the rings of the trachea are clearly visible, and at least as much of this tube is seen as it is intended to incise. During the progress of the dissection, all bleeding vessels are secured as far as possible; and if it happens that the necessary delay is of no importance, all hæmorrhage is arrested before the trachea is opened. The point of the knife (the edge being directed upwards) is then thrust into the trachea, and carried upwards to such an extent as at once to make an opening of sufficient length. During this part of the operation the trachea is steadied and the knife is guided by the left forefinger of the operator. The tip of the finger is at once glided over the opening made, so as to serve as a guide in the subsequent introduction of the dilator or canula, and in the meantime to prevent the entrance of blood. This stage of the operation may be accomplished in a somewhat different and probably better manner, especially if the patient is young, and the trachea is small, and has but little resisting power. Instead of using the finger, the trachea is seized by means of a sharp single or double hook, and is drawn somewhat forwards and upwards, and firmly held while the opening is being made and until the dilator or canula is introduced. The last stage of the operation varies with the object in view. If the operation has been undertaken on account of the presence of a foreign body, the edges of the opening in the trachea are at once separated as widely as possible either by blunt hooks, by dressing forceps, or by one of the dilating instruments especially made for the purpose, and the general plan described at p. 493 is pursued. If, however, the operation has been rendered necessary by laryngeal obstruction, the canula (already furnished with tapes for fixing) is introduced as speedily as possible.

Such is a brief description of the method of performing tracheotomy ordinarily recommended. But simple, easy, and safe as this method may seem in description, it is often complicated and difficult, and sometimes, from the delay involved, even dangerous in practice. Plenty of time, a good light, and, above all, skilful assistants, are absolutely necessary to enable the surgeon to accomplish his task with facility, if he adopt this method of operating. But it often happens that there is not a minute to be lost, and the surgeon must rely on himself alone. He may be called upon to operate at night, and there may be no good lamp at hand. Under such circumstances, it is impossible to make a deliberate dissection without endangering the life of the patient. Unskilful attempts to hook aside the divided structures embarrass rather than aid the operator. The natural laxity of the several layers of connective tissue of the neck is greatly increased by their division ; and the various parts become capable of being moved so easily, and to such an extent, that they are almost sure to be pulled more or less out of position, and their normal relations disturbed. Thus the surgeon may be misled, and seriously hindered in the accomplishment of his purpose.

It has happened, to my knowledge, that the cervical vertebræ have been safely reached before the trachea has been found. The trachea on the one side and the large vessels on the other were held scrupulously apart by the assistants who had charge of the retractors.* Mr. Marsh † alludes to a similar case.

In the absence, therefore, of skilled assistants and a good light, and especially if suffocation is impending, and every moment is of consequence, the following method should be adopted.

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* See Durham on 'Some of the Difficulty and Dangers of Tracheotomy,' *Practitioner*, April 1869, p. 226.

† Op. cit. p. 351.

The surgeon standing on the right side of the patient, who is firmly held in the position already described, makes a rapid but careful preliminary examination of the parts. He then places the forefinger of his left hand on the left side of the trachea, and the thumb on the right, and makes uniform, steady, deep pressure, until he is able to feel the pulsation of both carotid arteries. By now very slightly approximating the finger and thumb, the surgeon feels that the trachea is firmly and securely held between them, and he has the satisfaction of knowing that the safety of the great vessels is ensured. Moreover, the skin and superficial structures are rendered tense, and prevented from being moved downwards with the knife. The finger and thumb thus placed are not to be moved until the trachea is reached. In the next place, by a succession of careful incisions (not by a hasty plunge) the surgeon cuts confidently down on to the trachea. The finger and thumb accurately placed on either side, help him to judge the exact position of the median line, from which the knife must never deviate. And their pressure causes the wound to gape and the trachea to advance. The forefinger of the right hand is passed from time to time into the wound, 'to make assurance doubly sure,' that there is no important vessel in the way. When the trachea is reached (as may be known by the sensation communicated through the knife, or by examination with the right forefinger), it may either be opened at once, or it may be seized by a sharp hook, and opened as in the previously described method. If the trachea is opened without the use of the hook, the knife should be guarded, lancet-like, by the forefinger of the hand that holds it.

It will be observed that in operating in the method thus described, the trachea is firmly fixed throughout; and the violent convulsive up and down movements which commonly give rise to so much difficulty and embarrassment are effectually obviated. The pressure of the finger and thumb also prevents in great measure venous hæmorrhage during the operation; and, as a rule, there is no need to pause and seek the wounded vessel. The whole operation, from the first incision to the opening of the trachea, occupies so short a time, that the interference with the respiration caused by the necessary pressure is of no moment. I have adopted this method in nineteen cases, and in no instance have I had the slightest reason to regret the course pursued. In several, life would have been sacrificed, or at any rate imperilled, if a slow dissection had been attempted.

Besides the methods thus described others have been from time to time advocated by different surgical writers. But such methods do not appear to possess any peculiar advantages or merits entitling them to special description in these pages.

Various instruments called *tracheotomes* have been contrived with the view of rendering the operation more easy and less hazardous. But the use of all such instruments is condemned by practical experience; and that too, in spite of the undeniable ingenuity displayed in the construction of some of them. The surgeon who is competent to operate does not require anything of the kind; and in the hands of the incompetent such contrivances are likely to prove dangerous.

Whichever method of operating be adopted, the following general observations may be equally applicable.

1. With regard to *hæmorrhage*. Fatal hæmorrhage during the operation very rarely occurs, and need not be feared if only due care and promptitude are exercised. There can be no doubt that in some, if not many, of the so-called cases of fatal hæmorrhage, death has really resulted not from loss of blood, but from want of breath; and that, because the surgeon has been deterred by fear from completing his operation.

Nothing but gross carelessness, or utter loss of presence of mind on the part of the surgeon, or uncontrolled struggling on the part of the patient, can explain the opening of the innominate or carotid artery. Such an accident, however, has occurred. It certainly ought to be remembered that the innominate may cross the trachea higher than in the normal arrangement. But an artery of such size must be detected if proper examination of the parts is made. Nor ought there to be any difficulty in discovering and dealing with the abnormal artery 'as large as the radial,' which is described as having been sometimes met with in front of the trachea. The thyroidea ima, not unfrequently found in this situation, is rarely of sufficient size to give rise to serious hæmorrhage, if only its possible presence is borne in mind, and search is made for it in cases of arterial bleeding after the canula is inserted.

But although fatal hæmorrhage is very rare, yet bleeding to a very considerable and even alarming extent often occurs, especially in cases of sudden or rapid obstruction to respiration.

Such bleeding is almost always venous, and usually comes from some communicating branch or other of the anterior jugular or inferior thyroid veins. It is sometimes impossible to avoid these veins: but every endeavour should be made to do so by keeping strictly in the middle line. Any vessels that may be wounded should be at once secured by ligature or pressure, if practicable; but attempts to do this should not be persevered in to the risk of the patient. The rule has been laid down, and repeatedly quoted, that the trachea should never be opened until all hæmorrhage has ceased. If the surgeon invariably abides by this rule, he will assuredly sometimes have to wait until his patient is dead. It is useless to let the patient die from suffocation, while attempting to prevent death from loss of blood: and yet this has been done. In any case in which there is great venous congestion, and the patient is on the point of suffocation, the surgeon must go boldly but carefully on, and complete his operation as quickly as possible, in spite of what may seem almost frightful hæmorrhage. He must not hesitate in such a case to open the trachea, and introduce the canula even through a very pool of blood. When the canula is in position, and respiration is restored either by natural recovery or by artificial aid, the blood moves on through the before congested pulmonary capillaries; the right side of the heart is relieved from distension; the blood flows on in its natural course; the previously distended veins resume their normal dimensions; and the profuse hæmorrhage speedily subsides, or is easily arrested by pressure.

2. With regard to *the opening in the trachea.* In making the opening into the trachea, it is important to keep strictly in the middle line; otherwise, as pointed out by Mr. Paget, ‘the canula is likely to stand awry in the wound, and its extremity will be turned sharply against the mucous membrane of the trachea, and will not only cause irritation, but will quickly become blocked with mucus.’* It is also important not to thrust the knife too far into the trachea. Mr. Marsh mentions an instance in which ‘the scalpel was driven through both the anterior and the posterior walls of the trachea, and through the œsophagus till it struck the spine.’ But although the knife must not be thrust too far, it is almost more important to take care that it is thrust far enough, and that it is made to incise the trachea to

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* Marsh, op. cit. p. 351.

a sufficient extent. It must be borne in mind that the mucous membrane of the trachea, especially if inflamed and swollen, may be pushed before the knife instead of being penetrated; and also that false membranes lining the tube may similarly be pushed before the knife, and on its withdrawal may, valve-like, close the opening. If the opening first made into the trachea is too small, and escapes detection when sought, it is better to make a second opening at once, rather than to lose much time in searching for the first. Experience shows that comparatively little danger, or none at all, is likely to arise from such a proceeding.* If the opening made in the trachea should be larger than it need be, and the wound through the skin too small or too completely closed, air may escape by the side of the canula into the areolar tissue, and emphysema may result. This accident, however, is rarely met with, and is not, as a rule, of any importance. Absorption soon takes place.

3. With regard to *the introduction of the canula.* This is often found to be a matter of some difficulty; and cases have occurred in which the canula has been thrust, and allowed to remain until death in the areolar tissue surrounding the trachea.† In such cases, the pressure of the canula has further impeded the already obstructed respiration.‡

To facilitate the introduction of the canula, Trousseau,§ and, following him, most French surgeons recommend the use of dilating forceps. Trousseau's bivalve dilating forceps may be used for this purpose, or the trivalve forceps of Laborde (see Fig. 68, p. 494). In England, the bivalve canula of Dr. Fuller (see Fig. 71 p. 509), is somewhat in favour, on account of the comparative ease with which it may be inserted. Practically, however, it will be found by far the best plan to use the ordinary cylindrical canula mounted upon a blunt pilot trocar (see Figs. 70*c*, 74, pp. 509, 511). By this means, the introduction of this canula is rendered easier than that of the bivalve canula, to the use of which there are many objections; and the operation is simpler than when a dilator is employed. If the surgeon should not possess a trocar, an elastic catheter or bougie may be used as a substitute. But the long firm handle of the trocar renders the manipulation of the instrument so mounted much more easy.

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* A good illustration is mentioned by Holmes, op. cit. p. 323, note.

† Marsh, op. cit. p. 352.

‡ Holmes, p. 323.

§ See Trousseau, *Clinique Médicale,* 1868, t. i. p. 466.

4. With regard to *the completion of the operation.* In every case, however apparently hopeless it may have become, the surgeon should complete his operation. The tube should be introduced even though the patient have ceased to breathe before this can be accomplished; and the most persevering efforts should be made to effect resuscitation by aid of artificial respiration. Blood that may have entered the trachea must be sucked out by the mouth of the surgeon, or by means of a syringe (if the disease is of infectious nature); its entrance may be prevented; and its expulsion favoured by turning the patient on his face from time to time. Under such treatment recovery has been repeatedly effected in cases apparently the most hopeless.

The canula.—Attention to the size, shape, and general construction of the canula is of great importance. It should always be double; that is to say, it should consist of an outer tube which remains fixed in the trachea, and an inner tube which may be removed from time to time. Sometimes the canula is too short, and the neck-plate becomes buried in the wound. Sometimes it is too long, and presses against the œsophagus behind, and projects in front to a greater or less extent from the wound, in which case it is very liable to be forced out. The canulas in ordinary use are so curved that the lower extremity often impinges on the mucous membrane of the anterior wall of the trachea; and sometimes the convexity of the curve comes in contact with the posterior wall. In either case ulceration may be produced sooner or later, and very serious results may follow. 'Two cases have occurred in Guy's Hospital, in each of which ulceration so produced extended through the anterior wall of the trachea into the innominate artery. Fatal hæmorrhage of course ensued.' * Another instance of the same kind is recorded by Mr. Wood.† And even in cases in which there has been no reason for supposing that any large trunk has been perforated, serious and occasionally fatal hæmorrhage has occurred. Mr. Marsh ‡ states that four or five cases have come under his observation. Again, abscesses, bronchitis, pneumonia, pyæmia, and other more or less fatal conditions, have sometimes resulted directly or indirectly from the inflammation or ulceration set up by the canula. It is easy to understand that in all cases the presence of the canula is likely to set up more or less local irritation and inflammation, which may spread along the air tube. But that such serious results should ensue as those described, seems to indicate something wrong in the construction or management of the canula.

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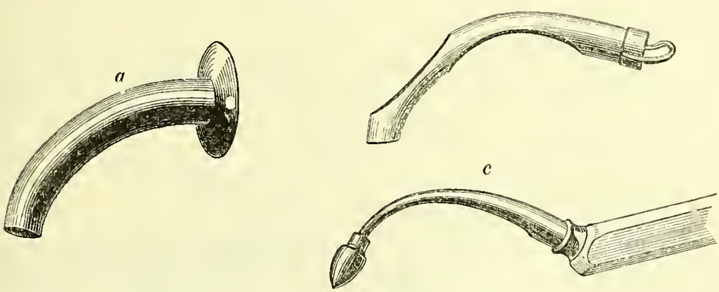
* Durham, in *Practitioner*, p. 220.

† *Path. Trans.* vol. xi. p. 20.

‡ Op. cit. p. 364. On the dangers due to the presence of the canula, see also Trousseau, op. cit. p. 477; H. Roger in *Archives Générales*; *Med. Times and Gaz.* vol. xix., Report on 'Tracheotomy.'

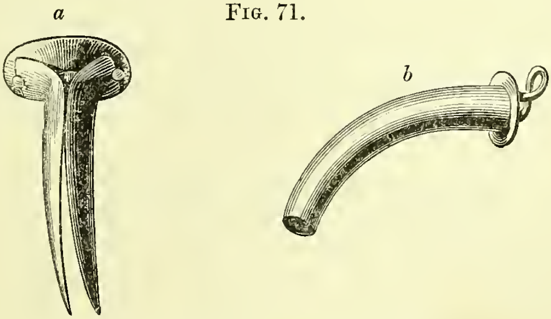
FIG. 70.



Ordinary Tracheotomy Canula. *a.* Outer tube. *b.* Inner tube. *c.* Blunt pointed pilot trocar.

The canulas ordinarily met with in this country are of three kinds. First, the ordinary English canula, which consists of an outer tube complete throughout (Fig. 70*a*), and an inner tube cut away on its convex and concave aspects (Fig. 70*b*), so as to facilitate its passage into and out of the outer tube. The curve of this canula represents about a quarter of a circle. Second, the

FIG. 71.



Dr. Fuller's Bivalve Tracheotomy Canula.
a. Outer portion viewed from behind. *b.* Inner tube, side view.

ordinary French canula, somewhat less curved. Both the inner and outer tubes are complete. Thirdly, the bivalve canula of Dr. Fuller, in which the outer tube is represented by two blades (Fig. 71*a*), which may be approximated by the finger and thumb during the introduction of the instrument, and are afterwards kept apart by the insertion of a complete inner tube (Fig. 71*b*), through which respiration is carried on.

In each of these forms, the canula is rigid throughout, and therefore is liable to press continuously upon any spot upon which it may impinge.

The improved French canula of M. Roger is so constructed* that though the neck plate is fixed, the tube in the trachea is allowed to move to a certain extent with the motions of the parts. Trousseau † states that since such canulas have been in use at the Hôpital des Enfans Malades ulcerations of the trachea have been much less frequently produced.

Canulas of the various forms described are made of different sizes. It has been repeatedly asserted that the canula should be as nearly as possible of the same calibre as the trachea into which it is to be inserted. But this is altogether a mistake, and any attempt to carry such an idea into practice cannot fail to be dangerous.

Mr. Marsh ‡ has shown by a series of careful measurements that the calibre of the cricoid cartilage is considerably less than that of the trachea. Mr. Holmes § has further shown, in a similar manner, that the area of the glottis when fully expanded is smaller than that of the transverse section of the cricoid. Moreover, it may be readily seen, on laryngoscopic examination, that during ordinary tranquil respiration the glottis never is expanded to its fullest extent. Thus it becomes evident that there is no need to employ a canula the calibre of which is anything like equal to that of the trachea. And a little consideration shows that it would certainly be unphysiological and probably dangerous to make the attempt. It may safely be accepted that the ordinary canulas are of sufficiently large calibre for the purpose intended.

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* The construction by which this is effected is adopted in the canula, Fig. 72, p. 511.

† Op. cit. vol. i. p. 477.

‡ Op. cit. p. 342.

§ Op. cit. p. 325.

With regard to their length and curvature, however, there is room for improvement, as is clearly indicated by what has been already advanced. With the view to obviate the possible sources of danger to which the canula may give rise, and some of the difficulties connected with its management, I recently devised the form of canula represented in Figs. 72, 73, 74.* The outer tube (Fig. 72) is so shaped as to pass straight back into the trachea, and then to turn downwards in such a manner that its extremity may lie in the middle of the trachea, and its edges may not press against the mucous membrane. The straight portion A slides in the collar B, but can be fixed at any point by means of the screw C. The length of the portion of the tube in the wound is thus easily regulated in accordance with the depth at which the trachea is situated. The projection of the end of the tube beyond the collar prevents mucus, &c., when once expelled, from being drawn in again by the next inspiration. The collar B is attached to the small plate D, which is loosely articulated with the neck plate E by means of two alar processes, which pass under little wire arches on E in such manner as to permit the portion of the tube in the trachea to accommodate itself in position during the various movements of the head and neck. The distal portion of the inner tube (Fig. 73) consists of several small pieces jointed together in the 'lobster-tail' fashion. The adoption of this construction enables this tube to pass

Fig. 72.

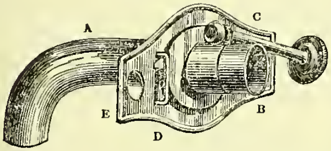


Fig. 73.

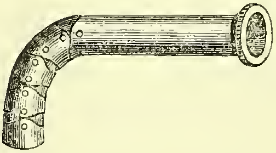
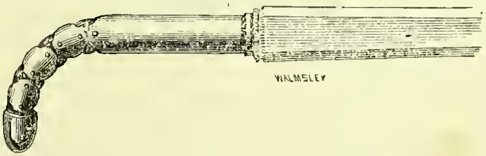


Fig. 74.



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* Made by Mayer and Meltzer.

easily into and out of the outer tube. The pilot trocar (Fig. 74) is constructed on the same principle. Experience has now amply shown that the advantages presented by this form of canula are not simply imaginary.

After-treatment, complications, and accidents.— After the operation is completed, and the paroxysmal fits of dyspnœa and violent cough which immediately follow the insertion of the canula have subsided, the patient usually experiences the greatest possible relief, and is soon ready to sink into a peaceful sleep. The edges of the wound should be approximated by means of a strip or two of sticking plaister, or may be left altogether open. Sutures, as a rule, should not be used. The surrounding parts of the neck should be well oiled over if the patient is suffering from diphtheria. And in such case it may be a good plan to apply nitrate of silver to the cut surfaces in the manner recommended by Trousseau. As a general rule, the simplest after-treatment only is requisite. But such simple treatment to be effectual requires the greatest vigilance, and sometimes considerable skill.

The patient should be surrounded by a warm and moist, but not oppressively close, atmosphere. The general temperature of the room should be uniformly maintained; and dishes of hot water, or some specially contrived apparatus, should be so arranged as to moisten the air the patient is about to breathe. Water kept boiling in a Florence flask by means of a spirit lamp may be made to answer the purpose; or a long tube may be attached to the spout of a kettle on the fire, and the steam which issues from it directed towards the patient's neck. It might be well if he could breathe the 'atmosphere of an orchid house'* without being in it. If the patient should unfortunately be placed in the midst of a large hospital ward, his bed must be partially surrounded by a tent-like arrangement of screens and blankets.

In most cases in which tracheotomy has been performed, especially in those in which it has been rendered necessary by croup, diphtheria, acute laryngitis, &c., the constant attendance of a vigilant and skilful nurse during a longer or shorter period is absolutely requisite. The superlative importance of careful watching, judicious management, and unwavering perseverance to the very end, cannot be exaggerated. For want of such watching, management, and perseverance in the after treatment, many patients have been lost. In such cases, the operation has usually been followed by immediate and intense relief, and it has been too readily supposed that nothing more need be done.

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* Cooper Forster, *Surgical Diseases of Children*, p. 54.

The special treatment required varies with the accident or disease which has rendered the operation necessary. If, for example, it has been performed on account of the presence of a foreign body, as soon as the foreign body is removed or expelled the canula may be removed, and the wound allowed to cicatrise. If it has been performed on account of croup or diphtheria, constitutional treatment may be necessary. If it has been performed on account of obstruction arising from the effects of syphilitic disease, constitutional as well as local treatment is called for. In all cases, however, it is requisite that blood, mucus, discharges, and membranes should be wiped away immediately on their expulsion from the canula, and that the inner tube should be withdrawn, cleaned, and replaced as often as may be needful. The dry tenacious stuff that so rapidly and firmly blocks the canula, and is sometimes so difficult to clean off, may be readily softened by immersing the tube in a weak solution of potash. Before reintroducing the inner tube, it should always be thoroughly oiled. When the period is reached at which the tube no longer requires constant watching and changing, it is a good plan to place over the neck of the patient a small light cradle on which two or three layers of moistened muslin are lightly laid. The air is thus moistened, and the entrance of dust, &c., is prevented.

The after dangers of the case arise in great measure from the progress or effects of the disease or accident which may have rendered the operation necessary.* But there can be no doubt that the operation itself, and especially the retention of the canula, may expose the patient to certain risks. Bronchitis and broncho-pneumonia not unfrequently result, and sometimes prove fatal. These affections may be caused, directly, by the admission of unwarmed, unmoistened air to the lungs; or indirectly by the extension of inflammation from a spot irritated or ulcerated by the pressure of the canula.

In all cases it is desirable to dispense with the use of the canula at the earliest possible period, not only to relieve the patient from the risk occasioned by its presence, but also to favour the restoration of the vocal apparatus to its normal state. The canula should be closed for a time by the finger or other means, and the attempt should be made to ascertain how far respiration can be naturally accomplished. The experiment should be persisted in at intervals, until it becomes evident either that the canula may be safely withdrawn, or that it would be hazardous to do so. The canula should not be withdrawn unless the patient can be watched by an attendant competent to replace it in case of need. Before withdrawing the canula, it should have been ascertained that the patient can breathe for some hours with the orifice plugged. Small silver plugs, with perforations of different sizes, may be advantageously used.

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* See the article in the *Practitioner* already quoted.

In some cases the muscles of the larynx waste, and become inactive from prolonged disuse. In other cases obstacles to the restoration of natural respiration arise from the presence of exuberant granulations which spring up around the tracheal opening.* In other cases, again, contractions of the diseased or injured part occur. In each class of cases an attempt should be made to remove the source of the difficulty: in the first class, by inducing exercise; in the second, by appropriate applications; in the third, by dilatation.

After the canula has been removed, the opening made, as a rule, speedily closes. It very rarely happens that any serious constriction of the trachea results; unless, indeed, a considerable portion has been injudiciously removed in the course of the operation.

In many cases the canula cannot be safely dispensed with until after the lapse of months or years; and it may be necessary during the remainder of life. In such cases it is very important to remove and examine the canula from time to time, for it is liable to undergo a process of slow corrosion. Mr. South mentions an instance in which the tubular portion became detached from the neck-plate and dropped into the trachea. Mr. Hilton has met with two similar examples. In each case the detached portion was successfully removed from the trachea by means of forceps, but not until after life had been seriously imperilled. If it should be necessary to wear the canula during a prolonged period, it is better to exchange the silver canula first employed for one made of vulcanite. Such canulas are much lighter, more comfortable to wear, and being less sharp, are not so likely to cause ulceration of the mucous membrane.

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* On such condition see the excellent paper of Mr. T. Smith, *Med.-Chir. Trans.* vol. xlviii. p. 227.

The diseases and accidents which render it necessary to make an opening into the windpipe are very various. The period at which the operation should be performed, and the spot at which the opening should be made, vary with the particular conditions which may demand the operation. These points are discussed in the several sections which refer to such conditions. In general terms it may be stated that one or other of the operations described may be necessary in any case of disease or injury which produces pathological or mechanical impediment to the free passage of air towards the lungs; and that in any such case the surgeon must be prepared to operate at any moment.

Foreign Bodies in the Pharynx.

Foreign bodies of various kinds often become fixed in some part or other of the pharynx. If thin and pointed, such as pins, needles, fish-bones, bristles, &c., they most frequently stick between one or other of the pillars of the fauces and the tonsil, or in the mucous folds connecting the base of the tongue with the epiglottis. If more bulky, such as portions of food, pieces of money, &c., they generally become arrested at or about the junction of the pharynx with the œsophagus, where the tube is narrowest and least easily expansible (the cricoid cartilage being in front), and where the muscular coat changes its character. However small the foreign substance may be, it occasions much discomfort until it is removed; and the sense of discomfort often remains some time after removal has been effected. A small pointed body sticking between the pillars of the fauces, or between one of them and the tonsil, causes more or less local pain, with a pricking sensation, increased on pressure behind the angle of the jaw. Sometimes there is considerable difficulty in swallowing, and pain on attempting to do so, accompanied by a disposition to vomit. Occasionally spasmodic contraction of the pharynx and œsophagus is excited. If the foreign body sticks in the mucous membrane at the root of the tongue, near the upper orifice of the larynx, in addition to the symptoms already mentioned, cough and more or less difficulty of breathing sooner or later come on.

An interesting case related by Mr. South * shows the severity of the symptoms that may be produced by a foreign substance in this situation, and also the care needful for its detection. A lady swallowing a morsel of food felt a sharp substance stick in her throat. She experienced constant pricking pain, and in the course of a few hours began to suffer from cough and repeated attempts at deglutition. Nothing being found on examination, the case was considered to be one of local irritation. In the course of twenty-four hours the symptoms became so aggravated as to threaten suffocation. She was seen by Mr. Tunaley, and tracheotomy was at once performed. On subsequent examination with the finger, the point of what was supposed to be a pin was felt when an attempt was made to swallow. The foreign body was removed by means of a pair of dressing forceps bent for the purpose, and proved to be a bristle about an inch in length. This was believed to have penetrated the mucous membrane at the root of the epiglottis, and to have produced spasm of the glottis by the irritation set up.

Sometimes a small sharp body may penetrate the pharyngeal walls, and give rise to serious or fatal hæmorrhage by wounding the carotid or some other important artery.

Mr. Joseph Bell † records the case of a lad who 'swallowed' a sewing needle with his food. He felt some pain, but the accident was not considered to be serious, until the ninth day, when he began to spit up blood. On the tenth day there was great hæmatemesis, and death took place in a few minutes. On examination, the larynx and trachea were found to be filled with clotted blood. So also was the stomach. The pharynx was transfixed opposite the middle of the thyroid cartilage by a sewing needle three inches long, the point of which had penetrated the common carotid artery.

Occasionally foreign bodies get into the pharynx from without by passing through the skin and other superficial structures.

Mr. Jardine Murray‡ relates a remarkable case in which he removed from the pharynx of a woman a sewing needle which had stuck into her neck half an hour previously.

Foreign bodies when large, as already stated, usually become impacted at the part where the pharynx becomes continuous with the œsophagus. Occasionally, however, they may be arrested higher up. A striking example is afforded by a case narrated by Mr. Paget.§

An old gentleman lying down faint, or in a slight epileptic seizure, got one of his sets of false teeth into his pharynx. He became half conscious, and for a time suffered from dyspnœa and a sense of choking. These symptoms subsided in a few days. He had, however, some difficulty in swallowing, which gradually increased. He had frequent short hacking cough. He felt constric-

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* South's *Chelius*, vol. ii. p. 384.

† *Medical Gazette*, 1842–3, p. 694.

‡ *Medical Times and Gazette*, May 7, 1859, p. 468. In this paper reference is made to numerous interesting cases both in man and the lower animals.

§ *Medical Times and Gazette*, Jan. 18, 1862, p. 58.

tion about his cricoid cartilage, but no considerable pain. The symptoms were not explained, for no examination was permitted. Four months after the accident he was seen by Mr. Paget, who, on depressing the tongue, indistinctly saw something white near the epiglottis, and on introducing his finger at once felt and easily hooked up the missing set of teeth. This consisted of a large palate plate with nine false teeth attached, and having spaces to fit round three remaining natural teeth. 'The piece lay between the base of the tongue and the epiglottis, very closely fitted to all the surface on which it rested.' It is certainly worthy of note that so large a foreign body should have remained in the pharynx without seriously obstructing respiration or absolutely preventing swallowing.

As a general rule, foreign bodies of large size, impacted in the lower part of the pharynx, speedily cause death from suffocation, either by compressing the upper part of the larynx or by producing spasm of the glottis. In some cases death occurs so suddenly that the patient is supposed to have died of apoplexy. Numerous instances are on record. Such an accident is most likely to happen if the pharyngeal muscles are partially paralysed.

Two cases of this kind have occurred within the last few years in Guy's Hospital. In each case the patient was under treatment for paralysis. In each death took place suddenly, during a meal; and on examination a portion of food was found in the pharynx pressing upon and completely closing the entrance to the larynx. Mr. South narrates the following curious example of arrest of a foreign body in the pharynx. A medical man, eating his breakfast in haste, suddenly felt choked. He could not swallow the morsel in his throat, and he could not breathe. He thrust his fingers back, and tried to pull out the portion of food. He succeeded in his attempt, and found that the piece of meat half-swallowed was attached by a thread of fibrous tissue to another piece which had became entangled in his teeth. This thread had pressed down the epiglottis, so that every effort to swallow only made him worse. A similar accident occurred to the same gentleman on a second occasion, and relief was similarly obtained.

Hard irregular substances, with sharp points or angles, as fragments of bone, impacted in the upper and back part of the pharynx, may cause ulceration, and lead to various serious complications. In some instances, caries of one or other of the upper cervical vertebræ has resulted.*

Mr. C. H. Moore † relates two cases in which deep-seated abscesses in the neck followed the impaction of foreign bodies in the pharynx. In each of these the foreign body was extracted externally after the abscess had been opened. In one case the foreign body was a piece of straw; in the other (under the care of Mr. Hulke) a husk of grass.

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* See cases by Fleury and Schupfe, quoted in *Nouveau Dictionnaire de Médecine et Chirurgie*, art. Atloïdienne, p. 797.

† *Lancet*, Sep. 10, 1864, p. 287.

Treatment.—In every case, the most careful attempts should be made to discover, and remove through the mouth, any foreign body that may have become impacted in the pharynx. Should such attempts prove successful, the patient is not only relieved from immediate pain and discomfort, but is spared from the risk he might have to encounter if the foreign body were pushed, or allowed to pass, further down the gullet.

The foreign body, if small and sharp, should be carefully sought by sight and touch; and when discovered, removed by the finger, or appropriate forceps. More harm than good is likely to result from indiscriminately and roughly wiping round the fauces with a sponge, on the chance of catching the foreign body.

The widely-opened mouth of the patient may be illuminated either by placing him opposite a good light, or by aid of the frontal mirror of the laryngoscope.* When the patient is made to inspire deeply, and the tongue is depressed, the soft palate becomes raised, and the pillars of the fauces are widely separated. Under such circumstances, a small, sharp extraneous substance sticking in the folds of the palate, or between them and the tonsil, may often be seen. Sometimes the laryngeal mirror, properly directed, may be used with very great advantage.

If the foreign substance cannot be seen, the finger may be introduced into the pharynx, and gently passed over the surface of the mucous membrane. Care should especially be taken to explore thoroughly the sulci between the pillars of the fauces and the tonsil. If the foreign body should be low down in the pharynx and beyond the reach of the finger, it may sometimes be detected by means of the laryngeal mirror, or by examination with a long probe, or slender properly curved forceps. If after thorough search the foreign body remains undiscovered, it is sometimes better to wait until the next day, rather than to proceed to the indiscriminate wiping round of the pharynx so often practised, and to which allusion has been already made. A bristle or a herring-bone, or any such substance, often becomes extricated after a time, and passes on down the gullet.

If a large foreign body seriously interferes with respiration, and is too firmly impacted to be at once removed, laryngotomy must be performed without delay. Further attempts at removal may then be made in safety; or if these fail, the foreign body may sometimes be pushed on into the stomach.

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* See the chapter on the LARYNGOSCOPE, in vol. iii.

Habicot * relates a very successful case of this kind. A lad, fearing to be robbed, attempted to swallow nine pistoles wrapped up in a piece of linen. The packet could not pass the narrow part of the pharynx, and suffocation impended from its pressure. The windpipe was opened, and the boy's life was saved. The pieces of gold were subsequently pushed on into the stomach, and were discharged from the anus eight or ten days afterwards.

Coins, arrested in the lower part of the pharynx, obstruct the passage of food and impede respiration in a degree varying, not only with their size and precise position, but also with the direction in which they lie.

I have, in two cases, extracted a halfpenny from this part of the pharynx, or the upper part of the œsophagus of a child. In one case the child had been absolutely unable to swallow even fluids since the accident, a period of six days, but respiration was scarcely affected. The child was almost starved to death. In the other case, the child had been able to swallow fluids tolerably well, but the breathing was somewhat impeded and croupy, and the voice was lost. A few hours only had elapsed since the accident, but there was considerable and increasing distress. In the former case the coin was lying with its flat surfaces upwards and downwards, and on the upper surface was a little heap of condensed alimentary materials. In the other case the coin was fixed obliquely across the food passage, and its edges were upwards and downwards. In each case the coin was extracted without difficulty by means of the 'money-probang' figured on page 524. In the case in which the coin was lying flat, some force was required to push the probang past it.

If the foreign body is very irregular, or covered with sharp projecting points, as an artificial tooth plate, and is too low down to be reached, or too firmly fixed to be removed without dangerous violence, the operation of pharyngotomy may be performed. This operation, which practically need not be distinguished from that ordinarily termed œsophagotomy, is discussed under this latter title on pp. 526 et seq.

A foreign body may remain in the pharynx for a considerable period.

Dr. Ogier Ward † records a case in which a halfpenny was impacted in the pharynx of a child during eight months. Stridulous breathing and difficulty in swallowing came on immediately after the accident. The child could only suck one mouthful of milk at a time, and was obliged to withdraw from the breast at each attempt to swallow. One morning, after a severe fit of coughing the day before, the child took the halfpenny out of his mouth and gave it to his father.

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* *Mém. de l'Acad. de Chirur.* t. xii. p. 243.

† *Pathological Transactions*, 1848–49.

The halfpenny was much worn and corroded, and was thickly coated with dried mucus and masticated food. The patient gradually recovered.

Monro mentions a case in which an extraneous substance, arrested at the termination of the pharynx, became lodged in a sac of some length which descended behind the œsophagus.

Rokitansky * remarks that 'sometimes small hard bodies, such as cherry stones, give rise to serious occurrences, by causing at different parts of the œsophagus, but chiefly at the lower constrictor of the pharynx, the formation of diverticula.'

It may reasonably be questioned, however, whether in such cases it would not be more correct to suppose that the small hard bodies got into, and perhaps increased, diverticula already existing, than to state that the diverticula were originated by the presence of the foreign bodies.

Foreign Bodies in the Œsophagus.

A foreign body may become arrested and fixed in any part of the œsophagus. Generally, however, lodgment takes places either opposite the cricoid cartilage, or just above the diaphragm: it is in these situations that the tube is most constricted, and that the foreign body is most readily held by muscular spasm.

The substances that have been retained in the œsophagus are very various. Among the most frequent are portions of food, such as pieces of crust, or imperfectly chewed meat, fragments of bone swallowed in soup, pieces of money, pins, needles, buttons, artificial teeth, &c.; less frequently, knives, forks, scissors, spoons, keys, &c. In one instance the handle of a punch-ladle was rammed down the throat, and became impacted in the œsophagus.† In another instance a boy got a large pike hook fixed in his own gullet.‡ Legouest § states, that small leeches are often swallowed, in drinking water, by soldiers in campaign. They are apt to attach themselves to the walls of the pharynx or upper part of the œsophagus, and to give rise to considerable discomfort, frequent desire to vomit, and intermittent flow of blood from the mouth.

The symptoms and ultimate effects vary with the size, shape, and angularity or pointedness of the substance, and the position in which it becomes fixed.

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* *Pathological Anatomy* (Sydenham Society's Translation), vol. ii. p. 12.

† Museum of Royal College of Surgeons. *Path. Catalogue*, vol. iii. p. 28.

‡ Dr. Gillespie, *Edin. Med. Journ.* 1859, p. 770.

§ *Chirurgie d'Armée*, p. 435.

If the foreign substance is small, it may simply produce irritation, with more or less dysphagia and pain in swallowing. Its long-continued presence, however, may excite inflammation, which may gradually go on to suppuration and ulceration.

If the foreign body is small in bulk, but pointed and sharp, as a needle, pin, &c., it may stick for a long time in the mucous membrane, and defy all attempts at removal. In other instances it may quickly become loosened by ulceration, and may be got rid of either by being vomited, or by descending into the stomach, and being voided with the fæces. Sometimes a foreign body of this kind penetrates the walls of the œsophagus, and subsequently pierces the trachea or the aorta, or finds its way on to some remote part of the body, and approaches the surface, and finally, after the lapse of months or years, becomes discharged through an abscess to which it has given rise. Sometimes fatal results speedily ensue.

A remarkable case is recorded by Mr. Andrew * as having come under his observation. A woman found on a doorstep in a dying state, was removed to University College Hospital. Before her admission she had ceased to breathe. On examination a fish-bone was discovered perforating the stomach close to the œsophagus, 'then the diaphragm and pericardium, and lastly the substance of the posterior surface of the heart; then inflicting a jagged wound in the middle of its septum, immediately over the right coronary artery and vein, and puncturing the latter vessel.' . . . . 'The pericardium was filled with a pint and a half of fluid blood, . . . poured out by the wounded vein.' It is very probable, according to the report, that the bone was first impacted in the lower part of the œsophagus, then reversed in direction by the passage of a portion of food, and lastly by muscular contraction forced through the walls of the tube.†

If a comparatively large, hard, and angular or pointed foreign body is retained in the œsophagus, deglutition is, as a rule, rendered more or less difficult or impossible; and other results of the most serious character may speedily follow.

Dr. J. W. Ogle‡ records a case in which a portion of bone, arrested in the œsophagus, set up ulceration of an intervertebral substance. Disease of the spinal cord followed. Mr. Duncan of Edinburgh § relates a case in which the metal setting of some false teeth stuck in the œsophagus. The sharp points caused ulceration, which extended through into the arch of the aorta. Fatal hæmorrhage ensued. Dr. Frederick Spry,|| of the 2nd Life Guards, brought before the Patho-

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* *Lancet*, Aug. 25, 1860, p. 186.

† See *Edin. Med. Journ.*, vol. vi. p. 471.

‡ *Pathological Transactions*, vol. iv. p. 27. The specimen is in the Museum of St. George's Hospital.

§ *Northern Journal of Medicine*, May, 1844.

|| *Pathological Transactions*, vol. xix. p. 219.

logical Society, in April 1868, a specimen illustrating the following interesting case. A trooper in robust general health, complained on March 24, 1868, 'of indigestion and oppression at his chest, the result, he said, of having . . . . on the previous Saturday, swallowed a piece of gristle, which seemed to stick half-way down.' Purgatives and emetics were administered, but without beneficial effect. Two days afterwards the patient seemed 'very ill. His countenance was pale and anxious, and he suffered very much from pain in the chest.' The pain increased and seemed to spread. In the afternoon he was able to swallow some milk. In the evening, after stooping, he suddenly vomited an enormous quantity of arterial blood, and fell back on his pillow dead. On post-mortem examination, there was found about the middle of the œsophagus 'a round blackish, ulcerated mass, the size of a threepenny piece,' in the centre of which a sharp spicula of bone projected. The bone was traced on into 'the aorta, in the ascending portion of which, about an inch and a quarter below the origin of the arteria innominata, a similar dark-coloured patch of ulceration was detected, enclosing the other end of the bone. Across the ulcer a rent had taken place, about one-fifth of an inch in length.' Mr. Bradley records the case of a 'smasher' who attempted to swallow a counterfeit half-crown. Eight months afterwards, death occurred from sudden profuse hæmorrhage. The coin was found to have produced ulceration of the gullet extending into the aorta.*

Foreign bodies of large size impacted in the upper part of the œsophagus, may endanger life by pressing upon the trachea, and obstructing respiration.

Notwithstanding the risks involved, it has happened in some instances that foreign bodies have been retained a considerable time in the œsophagus without producing any mischief.

In the case to which allusion has already been made, an insane gentleman rammed the whalebone handle of a punch-ladle down his throat, with suicidal intent.† The instrument was extracted after having been in the throat sixty-two hours, during which period the patient had eaten, drunk, and slept as usual. No ill result followed, and the next day the patient was free from complaint. Monro mentions a case in which a halfpenny was retained in the œsophagus of a boy during a period of three years. After death from consumption, the halfpenny was found closely embraced by the gullet. Another case is also mentioned by Monro in which a halfpenny was removed by means of a blunt hook, after having been impacted in the œsophagus for six months.

Diagnosis.—It is not always easy to diagnose with certainty the presence of a foreign body in the œsophagus. The history of the case and the sensations described by the patient may sometimes be delusive.

If the foreign body is large and is impacted in the upper part of the tube, it may sometimes be felt on external examination, or it may be at once detected on attempting to pass a bougie or sound. Cases, however, have occurred in which foreign substances of comparatively small size, although retained, have not been discovered, even after repeated and careful examinations. On the other hand, there may be much local pain, considerable difficulty in swallowing, and even interference with respiration, although no foreign body is actually present. Such symptoms may arise from abrasion of the mucous membrane, and subsequent inflammation produced by swallowing a large irregular substance.

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* *Med. Times and Gaz.* 1868, p. 447.

† *Pathological Catalogue of Royal College of Surgeons,* vol. iii. p. 28.

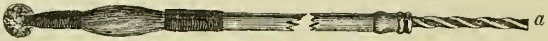
In the case of a sharp pointed body of small bulk the diagnosis may be very difficult. At a meeting of the Medico-Chirurgical Society of Edinburgh (Jan. 1859), Dr. W. T. Gairdner narrated the history of a woman who was supposed to be suffering from typhus, and was accordingly sent to the fever ward of the hospital. The symptoms in the main were those of double pneumonia, accompanied by a peculiar laryngeal cough. Death occurred forty-eight hours after admission. On examination, a fish-bone, which had passed through the posterior wall of the œsophagus, was found imbedded in pus in front of the vertebral column. There was pus in both pleuræ, in the lungs, and in the pericardium.

Treatment.—Any foreign body impacted in the œsophagus should be removed as soon as practicable. The method to be adopted depends to a certain extent upon the size and character of the foreign substance, as well as upon the position in which it is fixed.

If the extraneous substance is known to be of moderate size, and of such nature that it may be easily digested, or of such shape that it is not likely to be hurtful in its passage through the stomach and intestinal canal, it may be gently pushed on into the stomach by means of a long flexible probang to the end of which a piece of sponge or an ivory knob is firmly attached (Fig. 77, *a*). If such a substance, however, should be lodged in the upper part of the canal, attempts should first be made to remove it by the finger, or by means of long curved forceps. The risk of injuring the mucous membrane of the œsophagus by the passage of the probang is thus avoided. Sometimes when the substance is in this situation it may be displaced, and subsequently removed, by digital pressure along the side of the neck

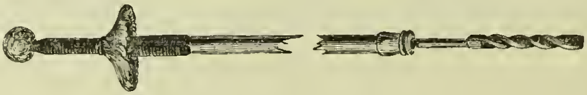
Small, hard, pointed substances, such as pins, needles, nails, fish-bones, &c., should always be removed if possible, rather than pushed on into the stomach. In some such cases a probang to which a piece of dry sponge is fastened may be successfully used; in others, a long flexible sound, with a skein of thread attached to its extremity may prove of service. The skein of thread forms a great number of loops, in some of which the foreign substance may be entangled. The probang thus furnished should be carefully passed beyond the supposed situation of the foreign body, and gently rotated during its withdrawal. The 'horse-hair' probang (Fig. 75) may be used in a similar manner. The instrument is passed beyond the foreign body in the condition shown in Fig. 75; then, by pulling the handle *a*, the horse-hair is made to spread out, as shown in Fig. 76. On gently rotating the instrument during withdrawal the foreign body may be caught and removed.

Fig. 75.



Horse-hair Probang.

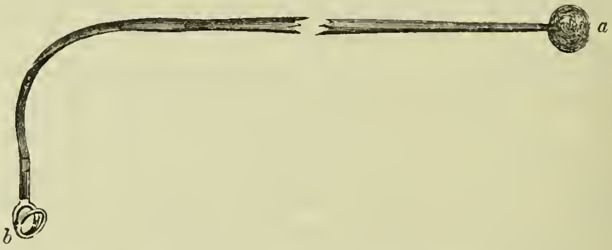
Fig. 76.



Horse-hair Probang, expanded.

It must be borne in mind that pointed substances are most likely to stick when they go with their points downwards; and that therefore attempts to push them on may often only result in burying them more deeply in the tissues. In some instances, however, in which the bodies are small and flexible, as herring-bones, bristles, &c., they may be safely pushed on. It occasionally happens that this is most easily effected by making the

Fig. 77.



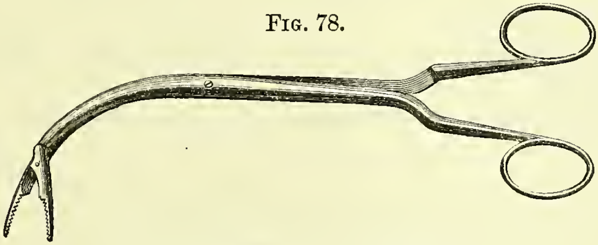
Probang with sponge at end *a*. Money-probang at end *b*.

patient swallow a large bolus of food, and immediately afterwards a draught of water.

Coins and such like bodies may often be extracted with comparatively little difficulty by means of a flat blunt hook connected by a thin slip of steel to the end of a long whalebone probang. (Fig. 77, *b*).

If the foreign body is large and hard, with rough angular surfaces or projecting points, as a piece of glass or stone, or a fragment of bone of considerable size, it should always be extracted if possible. Long, properly curved forceps are most likely to be of service in such a case. The œsophageal forceps ordinarily made, are of two kinds; in one the blades open laterally, and in the other antero-posteriorly. In some cases the former, in others the latter form is the more readily applicable.

Fig. 78.



Forceps for Extraction of Foreign Bodies.

The best mode of construction for the œsophageal forceps is that devised by MM. Robert et Collin of Paris, modified and improved by Messrs. Mayer and Meltzer of London. Fig. 78 illustrates the principle upon which these forceps are made. It will be seen that very slight separation of the handles causes very wide separation of the blades.

The forceps, well oiled and with the blades closed, should be passed gently through the pharynx, and along the œsophagus, and used as a sound or probe until the foreign body is touched. The blades may then be opened, and an attempt made to seize the foreign body. Should the attempt be successful, the foreign body may be withdrawn: but in doing this the greatest delicacy and the most careful manipulation are necessary in order to avoid lacerating the mucous membrane.

In some cases, if the stomach is full and no other means are at hand, vomiting may be excited, in the hope that the ejection of the contents of the stomach may displace and expel the extraneous substance. But this treatment is rarely successful. If the body is of large size and firmly impacted, and especially if its surface is rough or angular, continued and violent vomiting is not unlikely to give rise to laceration of the œsophagus. And if the body is small and pointed, vomiting may only render it more firmly fixed. But although, therefore, the administration of emetics cannot as a rule be recommended, it is right to state that cases are on record in which large portions of meat, impacted in the pharynx and producing urgent symptoms of suffocation, have been got rid of by vomiting induced by the injection of a solution of tartarized antimony into the arm.* Other cases are recorded in which tartarized antimony and sulphate of zinc administered internally have led to satisfactory results.†

In some cases in which small bones have been lodged in the œsophagus it would appear that the constant swallowing of the dilute mineral acids has been of benefit. Professor W. Hall of Baltimore, observes: 'When a small bone is lodged in the fauces or œsophagus, it may be decomposed, or rendered so flexible that it will pass into the stomach, by the patient frequently taking diluted mineral acids. By this means I have succeeded in removing a small chicken-bone from the œsophagus, across which it had remained firmly fixed for several hours, although an emetic had been administered, and the curved forceps and probang had been frequently used, without success.' It is right to allude to this method of treatment, but I venture to think it would be wrong to recommend its adoption.

When a foreign body, lodged in the œsophagus high up, obstructs respiration by pressure upon the trachea, tracheotomy must be performed. It may be possible to open the air tube below the point where it is compressed. But even if this is impossible, an elastic tube may be passed down through the opening made; and respiration may be relieved until the foreign body can be removed.

Œsophagotomy.—If a foreign body in the œsophagus or pharynx can neither be extracted nor pushed down, nor got rid of by any ordinary means, it should be removed by operation, without unnecessary delay. It is true that in some cases extraneous substances have remained in the œsophagus during very long periods without producing much distress, or occasioning any serious injury to the neighbouring parts. But it is equally true that in a large proportion of cases extensive suppuration and ulceration and very frequently fatal results have ensued. On the other hand the operation of œsophagotomy, or pharyngotomy, for the removal of foreign bodies has hitherto proved eminently successful. This operation may appear formidable in conception; but practically it is not difficult in execution, nor is it necessarily accompanied by any great risk. Experience shows that the chief danger is in delay. This is very forcibly urged by Dr. Cheever of Boston, U.S., in an excellent monograph on Œsophagotomy recently published.*

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* *Dict. des Sciences médicales*, t. vii. pp. 21, 22.

† Cooper's *Dictionary*, 7th edit. p. 1,026.

Mr. Cock, referring to the recorded cases, writes: 'It would appear that success has attended a speedy operation, whereas in those instances in which the use of the knife has been delayed until local inflammation, suppuration, or even sloughing has been established, and the patients' powers have been prostrated by fasting, pain, and want of rest, the operation has been fatal.† Again, Mr. Arnott, who was the first in this country to urge the importance and demonstrate the practicability of this operation, writes: 'The rule of practice ought to be, when a solid substance, though only of moderate size and irregular shape, has become fixed at the commencement of the œsophagus, or low down in the pharynx, and has resisted a fair trial for its extraction or displacement, that its removal should *at once* be effected by incision, although no urgent symptoms may be present.'‡

It is probable that further experience will prove that the operation may be advantageously performed even in cases in which the foreign body is much lower down in the œsophagus than indicated in the above quotation. Indeed, in one of Mr. Syme's cases the foreign body was opposite the top of the sternum, and in one of Dr. Cheever's just below the top of the sternum.

More or less complete details have been published of 21 cases of œsophagotomy for the removal of foreign bodies. A summary of them is appended in a tabular form, pp. 531-535. Of the 21 cases 17 were perfectly successful, and followed by recovery. In 4 cases the patients died. But in these cases the foreign bodies were removed, and in no instance could death be attributed in any degree to the operation. In one case (Mr. Arnott's) the patient died of pneumonia which existed before the operation was performed. In two cases (Demarquay's and Flaubert's) abscesses already existed. Respecting the fourth fatal case (Dr. Martini's) Mr. Cock § makes the following remarks, the justice of which will scarcely be disputed: 'When we read that the man was repeatedly bled, that sixty separate attempts at dislodgment were made with levers and forceps, that enemata of belladonna were employed, that finally tartar emetic was injected into the veins, followed up by clysters of vinegar and opium to counteract its effects; moreover, that during this ordeal the patient was unable to swallow even a drop of water, it is not surprising that he finally succumbed.'

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* *Two Cases of Œsophagotomy for the Removal of Foreign Bodies, with a History of the Operation*, by D. W. Cheever, M.D. 2nd edit. Boston, 1868.

† *Guy's Hospital Reports*, 3rd Series, vol. xiii. p. 8.

‡ *Med.-Chir. Trans.* vol. xviii. p. 93.

§ *Guy's Hospital Reports*, 3rd Series, vol. iv. p. 230.

Method of operation.—The side of the neck upon which it is better to operate, and the exact situation in which it is best to make the incision, depend upon circumstances. If on external examination the foreign body can be felt projecting on one side, the incision should be made on that side and directly over the projection. If, however, the foreign body does not project on one side more than on the other, it is better to operate on the left side, inasmuch as the œsophagus inclines rather to the left, and this side of the neck is in some respects the more favourable for the manipulation of the surgeon. The patient should lie upon his back, the head and shoulders should be slightly elevated, and the face turned somewhat towards the opposite side. An incision four or five inches in length should first be made through the integuments over the depression between the sterno-mastoid and the windpipe. The incision should extend from about opposite the upper border of the thyroid cartilage nearly as low as the sterno-clavicular articulation. The platysma myoides muscle and the cervical fascia are then to be divided. The edges of the wound being held apart, the omohyoid muscle may be drawn outwards or cut through. The outermost fibres of the sterno-hyoid and the sterno-thyroid muscles may be divided to such an extent as may be necessary. The carotid sheath, with the contained vessels, thus fully exposed, should next be carefully drawn outwards together with the sterno-mastoid, and retained by means of blunt retractors; and the thyroid body should be separated so far as may seem necessary and drawn inwards. The separation of these parts is best effected by means of the handle of the scalpel, or a round-edged scalpel, or simply by the fingers.

The larynx being now drawn somewhat forwards, and turned slightly upon its long axis, the finger may be passed behind it; and an attempt made to discover the position of the foreign body. If this cannot be done, a long pair of curved forceps should be introduced by the mouth, passed well down into the pharynx, and then opened, and made to press the walls of the tube well towards the wound. A good guide is thus ensured. An opening large enough to admit the finger should next be made into the œsophagus or pharynx. This opening may afterwards be extended upwards or downwards if necessary.

Lastly, the foreign body should be searched for with the finger, and when found, extracted by means of appropriate forceps. Any small blood-vessels, divided during the operation, should be at once tied. In the latter stages of the operation great care must be taken to avoid the recurrent laryngeal nerve, which ascends in the groove between the trachea and œsophagus. The wound should not be closed by sutures.

For the first few days after the operation the patient should be fed through an elastic catheter, or small œsophagus tube, passed through the mouth into the œsophagus beyond the wound. In a few days the ordinary œsophagus tube may be used.

Such is a brief description of what is doubtless the best method of performing œsophagotomy. This method at any rate has been adopted with unvaried success by Cock, Syme, and Cheever;* and certainly in the two cases in which I had the opportunity of seeing Mr. Cock operate, was carried out without any great difficulty.

Nélaton, who, however, writes apparently without any practical experience of the operation, and at the same time seems to entertain an exaggerated idea of its difficulty and danger, recommends a different method. He advises† that the incision be made in the median line, as in tracheotomy; that the sterno-hyoid muscles be separated; and the isthmus of the thyroid body be divided between two ligatures tied round it; and finally that the left lobe of the thyroid body be turned over, and the œsophagus sought and opened behind, and to the left of the trachea. This method would certainly appear to be much more difficult, if not more hazardous, than the lateral method, and also must be more liable to endanger the recurrent laryngeal nerve. It is worthy of note that this nerve, as a rule has escaped serious injury. In one of Mr. Cock's cases, the patient before the operation had an excellent tenor voice; afterwards, he could only sing bass.

The accompanying woodcuts (Figs. 79, 80) represent pretty accurately the tooth plates removed by œsophagotomy by Mr. Cock, to whose kindness I am indebted for permission to insert them in these pages. They serve to illustrate the general character of the foreign bodies that are most likely to render this operation necessary. When once such a body has become firmly impacted in the œsophagus, any attempt to remove it by forceps through the mouth must be well nigh hopeless; and to push it forcibly onwards must be extremely dangerous. On the other hand, ample experience shows that the early performance of œsophagotomy is likely to be attended by the most perfect success.

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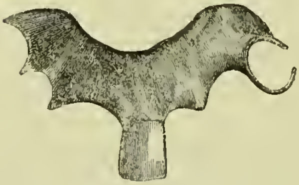
* See appended Table of Cases.

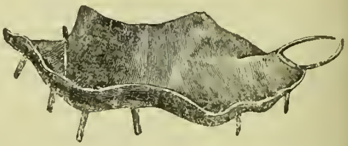
† *Éléments de Pathologie chirurgicale*, t. iii. p. 407.

Fig. 79.



The Tooth Plate and Tooth extracted in Mr. Cock's First Case of Œsophagotomy.

Fig. 80.



The Tooth Plate extracted in Mr. Cock's Second Case.

Œsophagotomy has been several times practised in cases of disease, with the view of establishing an opening through which to convey food to the stomach. But in no instance has any satisfactory result been achieved.* In such cases, therefore, experience as well as *à priori* reasoning would seem to be opposed to the operation.

In the following Table are summarised the details of all the cases of œsophagotomy for the removal of foreign bodies, which so far as I can ascertain, have hitherto been published. In compiling it, free use has been made of the Table in Dr. Cheever's excellent monograph, than which, however, it will, I believe, be found more correct.

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* See *Dublin Journal*, May, 1845. *Journal de Chirurgie*, par Malgaigne, t. iii. 1845, p. 371. Bruns, *Deutsche Klinik*, 1865, p. 37. A remarkable case quoted at length in the Sydenham Society's *Year Book*, 1866. These cases are referred to by Cheever. An additional case is recorded by Mr. Willett, *St. Bartholomew's Hospital Reports*, vol. iv. 1868, p. 204

TABLE OF CASES

In which the Operation of Œsophagotomy has been performed for the Removal of Foreign Bodies.

No.	Date.	Sex and Age.	Nature of Foreign Body.	Point of Impaction.	Treatment before Operation.	Operation, when performed, &c.	Result.	Cause of Death.	Operator and Authority.
1.	1738.	M.	Portion of bone, one inch long, six lines broad.	Œsophagus: exact point not stated.	Not mentioned.	Operation performed, and foreign body extracted.	Recovery.	—	M. Goursauld, 'Mém. de l'Acad. de Chirurgie,' t. iii. 1778, p. 14.
2.	—	—	Probably a portion of bone.	—	— —	Operation performed.	Recovery.	—	M. Roland, ibid.
3.	1832.	M.	Portion of beef-bone.	In œsophagus at lower part of neck.	Attempts made to dislodge it; body touched.	Operation on twelfth day after accident; bone extracted with difficulty, on left side of neck.	Speedy recovery.	—	M. Bégin, 'Journ. univ. et hebdom.' 1833, t. xi. p. 93.
4.	1832.	M.	Large conical fragment of bone.	Œsophagus; lower part of cervical portion.	Every means attempted to dislodge it; body touched.	Operation on eighth day after accident, on left side of neck.	Recovery.	—	M. Bégin, ibid.
5.	1833.	$2\frac{1}{2}$	Spinous process of one of the dorsal vertebræ of a sheep.	Lower part of pharynx.	Emetics, and various attempts to dislodge it.	Operation not allowed until five weeks after impaction; incision on right side.	Death, fifty-six hours after operation.	Pneumonia, which existed at time of operation.	Mr. Arnott, 'Med.-Chir. Trans.' vol. xviii.

TABLE OF CASES—*continued.*

No.	Date.	Sex and Age.	Nature of Foreign Body.	Point of Impaction.	Treatment before Operation.	Operation, when performed, &c.	Result.	Cause of Death.	Operator and Authority.
6.	1842.	M. 41	Portion of bone, dense, triangular; angles sharp.	Œsophagus—perforation of; body lying on carotid.	Repeated attempts at extraction. Frequent hæmorrhage.	Operation eighth day. On left side.	Recovery by the twenty-sixth day.	—	De Lavacherie, 'Mémoires de l'Académie Royale de Médecine de Belgique,' t. i. 1848, p. 126.
7.	1844.	M. 34	Portion of bone.	Could be felt from the exterior, projecting above the clavicle.	Bleeding, injection of tartar emetic in veins, enemata of belladonna, and sixty attempts at dislodgement by various instruments.	Operation four days after impaction; bone swallowed by patient during its performance.	Death, two days after the operation.	Collapse. Pharynx gangrenous. Stomach and duodenum inflamed.	Dr. Martini, 'Journal de Chirurgie,' par Malgaigne, t. iii. p. 336.
8.	1853.	M.	Small fish.	Pharynx; tail seen in mouth.	Vain attempts at withdrawal through mouth.	Operation after several days.	Recovery in six weeks.		Antoniesz, 'Lancet,' vol. ii. 1854, p. 260. (From 'Ceylon Miscellany,' vol. i. No. 2.)

9.	1853.	M. 44	Fragment of beef-bone.	Œsophagus in neck.	Vain attempts at extraction.	Operation on ninth day.	Death on second day after the operation.	Perforation in front and behind. Retro-pharyngeal abscess reaching to stomach.	Flaubert, 'Gazette des Hôpitaux,' 1857, No. 88, p. 349.
10.	1854.	F. 3½	Franc piece.	Upper part of œsophagus.	Repeated attempts at extraction with Graefe's sound and forceps.	Operation on tenth day.	Death third day after operation.	Retro-œsophageal abscess opening into pleura.	Demarquay, 'Gazette hebdom.' Nov. 1861, p. 701.
11.	1855.	—	Portion of bone.	Œsophagus: abscess formed.	Could not be reached through mouth.	Operation on sixteenth day.	Recovery in two weeks.	—	Syme, 'Clinical Surgery,' Edin. 1861, p. 91.
12.	1856	M.	Gold tooth-plate, containing one false incisor.	Junction of pharynx and œsophagus. No external projection.	Vain attempts at removal with forceps and other instruments; emetics.	Operation on fourth day; incision on left side.	Recovery in four weeks; voice permanently altered from tenor to bass.	—	Cock, 'Guy's Hospital Reports,' series iii. vol. iv. 1858, p. 217.
13.	1861.	—	Thin piece of mutton-bone, one inch square.	Œsophagus; no external projection.	Could not be reached from mouth.	Operation on sixth day.	Recovery in two weeks.	—	Syme, 'Clinical Surgery,' 1861, p. 94; 'British Medical Journ.' 1861, p. 91.

TABLE OF CASES—*continued.*

No.	Date.	Sex and Age.	Nature of Foreign Body.	Point of Impaction.	Treatment before Operation.	Operation, when performed, &c.	Result.	Cause of Death.	Operator and Authority.
14.	1862.	M. 21	Swedish copper coin, size of old penny.	Œsophagus; opposite upper part of sternum.	Coin had passed into gullet in November, in three weeks symptoms of obstruction disappeared and patient was discharged. Re-admitted in February, still feeling something in gullet. Coin touched by bougie.	Operation more than two months after the accident.	Recovery; could swallow in a week. Convalescent in a fortnight.	—	Syme, 'Edinburgh Medical Journal,' 1862, vol. vii. part ii. p. 1010.
15.	1863.	M. 22	Fragment of bone 35 mm. in length, 24 in breadth, 10 in thickness. Nature of body not suspected. Said to have been swallowed in a portion of bread.	Commencement of œsophagus.	Emetics; sound detected foreign body, the size and nature of which could not be made out. Attempts at removal by forceps, and at pushing down by probang, unsuccessful.	Operation sixth or seventh day, by lateral method.	Recovery; no bad symptom. Fed by tube for ten days. Wound perfectly healed in six weeks.	—	Sonrier, 'Gazette des Hôpitaux,' 1864, p. 66.
16.	1864.	F.	Peach stone.	—	— —	— —	Recovery.	—	Arnold, 'F. C. Morgagni,' vi. 1864, p. 352. (Quoted on the authority of Cheever.)
17.	1866.	M.	Portion of fin-bone of cod fish, one-half inch by one-fourth inch.	Junction of pharynx and œsophagus. No external projection.	Spontaneous vomiting; pharynx explored by finger and probang, causing rigors.	Operation on third day, incision on right side.	Recovery in six weeks.	—	Cheever, 'On Œsophagotomy for the Removal of Foreign Bodies,' Boston, 1868.

18.	1866.	M.	Brass pin, one inch and a quarter in length.	Just below top of sternum. No projection.	Vomiting; long probang passed without obstruction.	Operation on third day, incision on left side.	Recovery in five weeks; no adhesions.	—	Cheever, Ditto, ditto.
19.	1867.	M. 33	Silver tooth-plate, adapted to portion of gum occupied by upper incisors and canines, with projecting rivets upon which the false teeth were formerly fixed.	Junction of pharynx and œsophagus.	Repeated attempts with probang. forceps, &c. Could be grasped by the forceps, but not moved.	Operation on fourth day.	Recovery; could swallow milk on the fourth day, solids on eighth day; discharged well on fifteenth day; no permanent alteration of voice.	—	Cock, 'Guy's Hospital Reports,' series iii. vol. xiii. p. 1.
20.	1867.	F.	Brass pin.	Apparently opposite left side of cricoid.	Attempts during four months.	Operation after four months.	Recovery.	—	Hitchcock, 'Boston Medical and Surgical Journ.' July 16, 1868.
21.	1868.	F.	Supposed to be a pin.	Junction of pharynx and œsophagus.	Various attempts.	Operation after eight months, left side.	Recovery.	—	Cheever, op. cit. p. 32.

In neither of the last two cases was any foreign body found. They are only quoted here as illustrating the small degree of risk incurred in this operation. Out of the twenty-one cases, seventeen were followed by recovery; and in the four in which death occurred the complications which proved fatal existed before the operation was performed.

INJURIES OF THE PHARYNX AND ŒSOPHAGUS PRODUCED BY CONCENTRATED ACIDS AND CAUSTIC ALKALINE SOLUTIONS.

Concentrated acids and caustic alkaline solutions are sometimes swallowed accidentally, and sometimes with suicidal intent. The effects produced vary with the nature, quantity, and strength of the fluid swallowed, and also to some extent with the amount of food, &c., in the stomach at the time. If the poison, whether acid or alkaline, is very concentrated, and taken in large quantity, more or less complete destruction of the mucous membrane of the pharynx, œsophagus, and stomach commonly results. The stomach (especially if empty) may be perforated, and the neighbouring parts seriously implicated. In such cases death usually ensues in from eighteen to twenty-four hours or less. If the poison is more diluted, violent inflammation of the mucous membrane of the fauces and œsophagus is excited. Lymph is effused on the surface, and into the submucous areolar tissue. Pain and difficulty in deglutition result. Ulceration often occurs, and is followed by thickening of the walls of the œsophagus, and constriction of its calibre. In some such cases slow recovery takes place; but much more frequently the constriction remains permanent; and finally the obstruction becomes impassable, and the patient dies of starvation.

When one of the concentrated mineral acids is swallowed, the patient immediately suffers violent burning pain in the fauces, œsophagus, and stomach. The mucous membrane of the lips and mouth is excoriated or corroded, and appears whitish or yellowish in colour. Sometimes it resembles soaked parchment. In one instance (mentioned by Dr. Taylor)[*] in which sulphuric acid had been taken, ‘the appearance of the mouth was as if it had been smeared with white paint.’ Thick ropy mucous stuff, consisting of saliva, mucus, and corroded membrane, escapes from the mouth. Retching and vomiting come on almost at once, and continue incessantly, or are easily re-excited by attempts to swallow.[†] Whatever is swallowed is immediately ejected. The vomited matter is usually more or less viscid, and of a dark coffee-ground colour. There is generally great difficulty in speaking and swallowing, and sometimes in breathing, from swelling of the mucous membrane of the fauces and larynx. The countenance becomes more or less livid, the skin cold and clammy, and the pulse quick, small, and feeble, or almost imperceptible. There is usually considerable thirst; the bowels are constipated, and if any evacuations take place, they are commonly either of a dark brown or leaden colour, but in some instances almost black from an admixture of altered blood.* There is great physical anxiety and distress; but the intellectual faculties, as a rule, remain clear. Exhaustion advances speedily; and death often occurs very suddenly.

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[*] *Medical Jurisprudence*, by A. S. Taylor, M.D., 1865, p. 160.

[†] ‘In a case of poisoning by sulphuric acid, reported by Dr. Geoghegan, the patient vomited for three or four hours. This symptom then ceased, and did not recur, although the woman did not die until thirty-four hours after the poison had been swallowed.’ Taylor, op. cit. p. 160, and *Medical Gazette*, vol. xlviii. p. 328.

After death, the mucous membrane of the mouth and tongue is found to be whitish, or yellowish, and more or less softened and corroded. If nitric acid has been taken, the characteristic yellow staining to which it gives rise may sometimes be recognised. The mucous membrane of the pharynx and œsophagus is corroded, and of a brownish or ash-grey colour; sometimes it appears blackish and charred in spots and patches, and under such patches effused blood is found. Cases, however, have been met with, in which the mouth, throat, and gullet have escaped almost uninjured.† The stomach is sometimes softened and perforated; but if not, it is generally collapsed and contracted. Its mucous membrane is intensely inflamed throughout or in parts; and is often covered by dark brown or black pitch-like stuff, which consists of mucus and altered blood. When this stuff is removed, the mucous membrane may be seen to be traversed by blackish or dark crimson lines of inflammation.‡

If the patient recovers from the immediate effects of the injury, he is still liable to suffer from various more or less remote effects, which may give rise to prolonged suffering, and ultimately prove fatal. Among such may especially be mentioned ulceration and constriction of the stomach with permanent impairment of its functional power, and stricture of the œsophagus.

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* Taylor, op. cit. p. 160.

† See cases by Dr. Ogle, *Med. Times and Gazette,* April 21, 1860. Mr. Dickinson, *Lancet,* 1853, p. 502, &c., quoted by Taylor.

‡ For numerous illustrative cases, see Taylor, *Med. Jurisprudence*; Taylor *On Poisons,* i.; *Guy's Hospital Reports,* Series I. vol. iv. p. 10. p. 297; Series II. vol. iv. p. 396; vol. v. p. 167; vol. vii. p. 211; Series III. vol. v. p. 134. Casper's *Forensic Medicine* (Sydenham Society Translation), vol. ii. p. 75.

Dr. Wilson * has recorded an interesting case, in which death resulted from the effects of sulphuric acid swallowed forty-five weeks and three days previously.

Six months after the acid was swallowed the patient ejected, during a violent fit of coughing, a cylindrical tube eight or nine inches in length. The chief symptoms which subsequently occurred, and preceded death, were great difficulty in swallowing, pain extending from the pit of the stomach to the shoulders, and expectoration, at intervals so copious that as much as two pints of frothy mucus were discharged in the course of twenty-four hours.

When a strong alkaline solution is swallowed, the patient experiences an acrid caustic taste, followed by a sensation of burning heat extending from the throat to the stomach. Vomiting sometimes occurs, but not always. The ejected matters are generally of a dark brown colour, and mixed with blood and shreds of membrane. The surface becomes cold and clammy, and the pulse quick and feeble. But in some cases intense heat of skin has been noticed.† There is often more or less purging, and colicky pain in the abdomen. 'In the course of a short time, the lips, tongue, and throat become swollen, soft, and red.' ‡ Death may occur within a few hours; or the immediate effects of the injury may be recovered from.

The post-mortem appearances ordinarily found in cases in which death has speedily resulted are as follows. The mucous membrane of the mouth, pharynx, and gullet, presents more or less manifest indications of the local action of the caustic. Sometimes it is inflamed; and patches of a dark chocolate or blackish colour are seen: sometimes it is softened, and detached. The mucous membrane of the stomach is partially inflamed, and may be eroded in places; or it may be puckered and blackened.

In the case of a child, a year and a half old, who died in Guy's Hospital twelve hours after having swallowed a mouthful of soap-lees, the following appearances were found.§ 'The mouth and tongue were slightly excoriated and of a light brown colour. The mucous membrane of the fauces, tonsils, and pharynx, had a slightly swollen appearance, and was of a similar yellowish brown hue. The whole of the œsophagus was in a somewhat similar condition, the mucous membrane having a brownish colour, particularly along the rugæ. The membrane was changed in character by the alkali, but nowhere destroyed. The greatest pernicious effect had been produced at the very extremity of the œsophagus, where the interior was of a dark brown colour; this terminated at a definite line, the mucous membrane of the stomach immediately below being quite unaffected . . . . Near the pyloric end of the stomach, there were a few rugæ of a very dark brown colour, produced, no doubt, by the action of the alkali. The mucous membrane thus altered was not at all soft; nor could it be stripped off, but on the contrary was hard and had a horny feel . . . . The larynx was almost closed above by the greatly swollen epiglottis. Upon raising the epiglottis, and looking into the larynx, the passage was seen to be quite free, the vocal cords not having been touched.'

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* *Medico-Chirurg. Trans.* vol. xxi.

† This symptom was especially observed in the case of the child whose symptoms are detailed in the text. See *Guy's Hospital Reports,* 3rd Series, vol. v. p. 133.

‡ Taylor, op. cit. p. 181.

§ *Guy's Hospital Reports,* 3rd Series, vol. v. p. 133.

The following case, recorded by Dr. Barclay,* furnishes a good illustration of the after effects that may result from swallowing a strong alkaline solution.

A woman, aged forty-four, was admitted into St. George's Hospital on May 2, 1853, about six hours and a half after having swallowed a quantity of 'American potash'—probably a saturated solution of carbonate of potash. She had vomited directly after taking it. The mouth and fauces were much corroded.

On introducing the tube of the stomach-pump some shreds of softened mucous membrane clung to it. There was great pain in the fauces, œsophagus, and at the epigastrium, but no tenderness on pressure. There was a little vomiting two days after admission. Deglutition was difficult; and pain was felt after the passage of food into the stomach. At the beginning of June, there was frequent vomiting, pain in the abdomen, tenderness on pressure, and constipation. After a time nothing could be retained in the stomach; food and medicine caused much pain, and were soon rejected. The patient, during a short period before death, was sustained by nutritive enemata. She died of inanition, July 8, about two months after having taken the alkali. On inspection, there were found at the upper part of the œsophagus, opposite the cricoid cartilage, three dense cicatrised bands, apparently the results of previous ulceration. The lower part of the œsophagus was much contracted, the lining membrane being entirely destroyed, and the muscular coat exposed. The external coats were much thickened. The cardiac orifice of the stomach, where the ulceration ceased, was so much contracted as hardly to admit a director. At the pyloric end the mucous lining presented a large and dense cicatrix, which obstructed all communication with the duodenum, excepting through an orifice no larger than would admit a probe. The intervening portion of the stomach was healthy—as were also the small and large intestines.

Dr. Basham † has recorded a case in which the fatal result was still more remote. The patient accidentally swallowed some soap-lees. The first symptoms of irritation and inflammation subsided. Within a few weeks there was some slight difficulty in swallowing; but it was not until eleven months afterwards that the dysphagia became very severe. Death did not occur until two years and three months after the accident. There was very tight stricture of the œsophagus. The stomach was unaffected.

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* *Medical Times and Gazette*, 1853, p. 554.

† *Lancet*, March 2, 1850. *Med.-Chir. Trans.* vol. xxxiii. In this paper short records are quoted of cases under Sir C. Bell, Mr. Cumin, and Mr. Dewar.

Strong solutions of ammonia when swallowed, produce effects very similar to those caused by solutions of potash and soda; but the sense of heat and the burning pain are more intense in the former than in the latter case. Ammoniacal solutions, furthermore, are especially liable, from the volatility of the gas, to affect the respiratory organs. In some cases it may be difficult to decide whether death has resulted from suffocation, from shock, or from the immediate effects of damage to the mucous membrane of the alimentary canal.

Christison refers to a case in which a strong dose of solution of ammonia caused death by suffocation in four minutes. In another instance a man suddenly swallowed a drachm and a half of liquor ammonia. He fell instantly to the ground, and soon died, after suffering the most excruciating pain.* In a case that came under the observation of Mr. Hilton,† a gentleman swallowed a quantity of strong solution of ammonia in mistake for sal volatile. The mucous membrane of the mouth and throat was corroded and dissolved. The difficulty of breathing was very great. Death occurred on the third day. On post-mortem examination the mucous membrane of the gullet was found to be softened, and at the lower part near the junction with the stomach was completely dissolved and destroyed. There was an aperture in the anterior wall of the stomach through which the contents had escaped. The mucous membrane presented a blackened and congested appearance, resembling that produced by sulphuric or oxalic acid. The immediate cause of death was believed to have been obstruction of the air tubes resulting from inflammation. 'The lining membrane of the air passages was softened and covered with layers of false membrane, and the larger bronchi were completely obstructed by casts.'

The following case illustrates the more remote effects of swallowing a strong ammoniacal solution.

A female, aged nineteen, was admitted into St. George's Hospital on September 2, 1853, who, eight weeks previously, while in an unconscious state, had been made to swallow a quantity of hartshorn. She immediately felt severe pain in the stomach, and in an hour or two became sick and vomited some blood. Hæmatemesis continued during three days. From the first there was great irritability of stomach, and constant rejection of food. The bowels were constipated. There was great emaciation and loss of strength. Death from starvation occurred three months after the poison was swallowed. On inspection, the œsophagus was found to be healthy, excepting at the cardiac orifice, which was slightly contracted. On the posterior wall of the stomach, was a dense cicatrix of the size of half-a-crown, and from its margins fibrous bands diverged in various directions. The pyloric orifice was contracted to the size of a crowquill. The other parts of the intestinal canal were healthy.

Treatment.—The poison, whether acid or alkaline, should be neutralised, and its immediate effects obviated, as speedily and as completely as possible, by aid of the stomach pump. A large quantity of water, or other diluent, as milk, thin gruel or barley-water, should be introduced into the stomach, and then pumped out. If acid has been taken, carbonate of soda, or magnesia should be mixed with the diluent in considerable proportion. Chalk and whiting, or the scrapings from a whitewashed wall or ceiling are materials commonly at hand; and in many cases they are very appropriate. But if sulphuric acid has been taken, it must be recollected that lime compounds will form sulphate of lime, which from its rapid absorption of water may give rise to some difficulty, unless a large quantity of diluent is used, and the pumping out is rapidly accomplished. In some instances a solution of soap has been advantageously used If alkali has been taken, vinegar or some other vegetable acid, if at hand, should be mixed with the diluent; or oil may be administered.

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* *Journal de Chimie médicale,* 1845, p. 531.

† Described in detail by Taylor, op. cit. p. 183.

In many cases stains about the mouth, or on the clothes, indicate the nature of the poison that has been taken. Sometimes the patient is able and willing to give information. But if neither indication nor information is afforded it is better to introduce the diluent at once, and to ascertain, by pumping out some of the contents of the stomach, what neutralising agent is required. The whole length of the œsophagus should be carefully washed.

When the stomach has been completely cleared of the poison, means should be adopted to allay the sufferings of the patient, and to prevent as far as possible the supervention of dangerous inflammation. Opium may be administered in the form of suppository; or morphia may be given subcutaneously. Hot anodyne and counter-irritant fomentations may be applied over the stomach; and, somewhat later, leeches may be of service. Food should be given very sparingly, or not at all, for some short time. The more perfectly at rest the injured parts are kept, the better. Demulcent drinks, as milk, barley-water, &c., may be supplied to allay the thirst so often experienced. Nutrient enemata, with opium, may be advantageously given.

When the first inflammatory symptoms have subsided, an œsophageal bougie should be passed, even before symptoms of dysphagia appear. The use of the bougie should be continued daily during a considerable period. If the quantity and strength of the poison swallowed, and the symptoms that have arisen, render it probable that the œsophagus has been severely injured, it is desirable to pass the bougie at intervals, long after there is any apparent necessity. In such cases experience shows that stricture of the œsophagus is almost certain to occur, sooner or later, however slowly and insidiously it may come on.

If the occurrence of stricture has not been prevented, it is of the greatest importance to recognise its existence at the earliest possible period, and to adopt proper treatment without delay.

If recognised early, strictures of the œsophagus resulting from the injuries under discussion may generally be dilated by the passage of bougies. The bougie should be shortly conical at the extremity. It should be passed with caution into the stricture, and retained there for ten minutes or a quarter of an hour at a time, or even longer if it can be borne. Or a small cylindrical bougie may be passed, if possible, through the stricture, and similarly retained. The introduction of the bougie must be repeated daily.

Great perseverance and patience are requisite. Mr. Cumin * records a case in which stricture of the œsophagus resulted from the effects of 'American potash,' swallowed by mistake. The passage of bougies ultimately proved very successful. But unremitting attention was requisite during ten months before normal deglutition was restored. Mr. Hutchinson † relates a case under the care of himself and Mr. Mead of Hackney, in which a satisfactory, though perhaps less completely successful result was obtained in a much shorter time. The patient had accidentally swallowed some caustic potash three months previously. The symptoms of contracting stricture of the œsophagus steadily developed themselves. When seen by Mr. Hutchinson, the patient seemed rapidly sinking. She had swallowed nothing for several days. Attempts were made to pass bougies of various sizes, under chloroform. The upper of two strictures which existed was passed by a large bougie; but a No. 8 catheter would not even enter the lower one. The next day, however, the patient was able to swallow a little fluid nourishment. Ten days later, the end of a No. 6 urethral bougie was passed well into the stricture, but not through it. During the week following food was taken fairly, and the patient improved in condition. The improvement continued. A year subsequently the stricture still existed, and solids could only be swallowed when carefully minced; but the patient was in better health than she had been for years.‡

Such cases may well serve to encourage the surgeon in the persevering use of bougies.

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* See Dr. Basham's paper, *Med.-Chir. Trans.* vol. xxxiii.

† *London Hospital Reports,* vol. iv. p. 56.

‡ Mr. Mead kindly informs me that the patient is still in excellent health, and able to swallow fluids and minced meat with care. More than two years have elapsed since she was under treatment.

In some instances it would appear that the administration of mercury and chalk combined with Dover's Powder has been beneficial.

Gastrotomy.—It sometimes happens, either in consequence of the age or condition of the patient, or of the extent or impermeability of the stricture, that all attempts at dilatation by bougies are in vain. In such case the patient must inevitably die of starvation unless an artificial way into the stomach can be established.

Now it has been abundantly proved by operations for the removal of foreign bodies that the stomach may be opened with comparative impunity.* Numerous cases are on record in which wounds implicating the stomach have been followed by permanent fistulæ. And further, no difficulty has been experienced in establishing fistulous openings into the stomachs of healthy animals for purposes of physiological research. The consideration of these and such like facts has suggested, and would seem to justify, the attempt to make a new way into the stomach in any case in which the œsophagus is absolutely and permanently obstructed, whether by the effects of injury, or as the result of disease.

Sédillot of Strasburg,† appears to have been the first to perform the operation of gastrotomy (or, as he terms it, *gastro-stomie*), on account of stricture of the œsophagus. Some years later, but without any knowledge of Sédillot's attempts, Dr. Habershon suggested, and Mr. Cooper Forster performed the operation for the first time in this country.‡

About a year subsequently, Mr. Cooper Forster performed the operation in a second case, the particulars of which are especially deserving of quotation in these pages. The patient, a child four years and four months old, was admitted into Guy's Hospital, under the care of Dr. Addison, on February 2, 1859. Seventeen weeks previously he had swallowed some corrosive poison, supposed to be a solution of potash. Violent vomiting immediately occurred; and either at the time, or at a subsequent period, the vomited matter contained two or three teaspoonfuls of blood. Fifteen weeks after the accident marked dysphagia came on, and gradually increased in severity. On admission there was pain in the throat and epigastrium. The child was much emaciated. He had swallowed some beef tea two days previously, but nothing since. Injections of beef tea and wine were administered every four hours, and half a grain of calomel was given twice a day. During a fortnight or so improvement appeared to take place.

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* See Table of Cases, p. 549.

† See the very elaborate and interesting chapter on the subject in Sédillot's *Contributions à la Chirurgie*, 1868, vol. ii.

‡ *Guy's Hospital Reports*, 3rd Series, vol. iv. pp 1–18.

But after a time the difficulty of swallowing again increased. On March 12, he was very much exhausted, and seemed to be sinking fast. He had not swallowed anything for two days. The next day gastrotomy was performed, under chloroform. Food was administered at frequent intervals through a tube passed into the stomach through the opening. The child seemed very comfortable, and enjoyed being fed. On the morning of the fourth day after the operation he suddenly complained of great pain over the abdomen: he became collapsed and cold, the eyes were sunken, and the pulse was almost imperceptible. He quickly sank into a comatose state, and died. On post-mortem examination, it was found that a large part of the œsophagus had been affected. The middle two fourths were constricted by thickening and induration of the submucous tissue; and a small sloughy spot existed at the commencement of the strictured part of the tube. The wound in the abdominal parietes had begun to slough, and the stitches were loosened. Recent general peritonitis had resulted from escape of some of the contents of the stomach into the cavity. The mucous membrane of the stomach was healthy, but was dark in colour round the opening.*

Before gastrotomy is attempted, care should be taken to ascertain that the stomach itself is comparatively healthy, and that all serious disease or constriction is confined to the gullet.

Method of operation.—The operation is performed in the following manner. Chloroform may be administered or not, according to circumstances. It should be given unless the patient can be relied on to remain perfectly still. Experience shows that troublesome vomiting is not so commonly produced as might be anticipated. The patient lies flat on his back in bed. The surgeon, standing on his right side, makes a perpendicular incision three or four inches in length through the integuments over the upper part of the left linea semilunaris. The aponeuroses of the abdominal muscles, and the transversalis fascia are then divided on a director to a corresponding extent. The outer border of the rectus muscle may or may not be seen.

The peritonæum is next opened, and the anterior wall of the stomach, which may be readily recognised, is brought into view. Or the great omentum may be seen lying in front of the intestines. In the latter case, gentle traction upon the omentum, and upward extension of the wound, may be requisite. The anterior wall of the stomach is then drawn well forwards into the wound, by means of strong ligature silks passed through it, or by sharp hooks. An opening an inch in length is next made into the stomach midway between the greater and lesser curvatures, and as near the cardiac end as practicable. The opening should be perpendicular in direction. Care must be taken that none of the contents of the stomach escape into the peritoneal cavity. Lastly, the margins of the aperture are carefully sewed to the edges of the opening through the abdominal parietes by several stitches, or by an uninterrupted suture. It is very important to adapt accurately the cut edges of the mucous membrane to those of the skin. At least a third, or even half an inch, of the stomach-wall should be included in the sutures. The portions of the external wound above and below the part occupied by the stomach are closed by sutures. There is little or no difficulty in the accomplishment of the operation, and no immediate risk is encountered. Such is an outline of the method practised by Cooper Forster, and adopted by Sydney Jones, Curling, and myself. Sédillot* recommends a crucial incision through the upper part of the left rectus muscle. But this method does not appear to possess any special advantages, and it is open to several obvious objections.

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* *Guy's Hospital Reports,* 3rd Series, vol. v. p. 1 et seq.

After the operation, the patient may be fed at such periods as may seem desirable through a tube introduced into the stomach; or by means of a spoon, or some such instrument, nourishment may be poured in little by little. It would probably be better if the patient could be supported entirely by enemata for some days, so as to avoid disturbing the edges of the wound, and interfering with adhesion. Strips of oiled lint may be placed round the wound, and warm fomentations applied over the abdomen. Mr. Hutchinson † suggests that a large silver tube should be retained in the opening, and ice-bladders kept on the abdomen.

Gastrotomy on account of obstruction of the œsophagus, has been performed in nine cases, all of which have terminated fatally. Sédillot, Cooper Forster, and Sydney Jones, have each operated in two cases, and Fenger (of Copenhagen), Curling, and myself, in one case each. The particulars of these cases are summarised in the appended Table.

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* Op. cit.

† *London Hospital Reports,* vol. iv. p. 58.

TABLE OF CASES

In which the Operation of Gastrotomy has been performed on account of Stricture of the Œsophagus.

No.	Date.	Sex.	Age.	Nature of Stricture, &c.	Mode of Operation.	After-Treatment.	Result.	Cause of Death.	Operator and Authority.
1	1849	M.	52	Epithelial cancer of the œsophagus. Symptoms of obstruction of five months' duration; rapidly increasing in severity; great debility; absolute inability to swallow; passage of bougie impossible; frictions; local applications; nutrient enemata.	Chloroform given. Crucial incision through skin over rectus. Sheath and muscle similarly cut through, and peritonæum divided; great omentum exposed; by drawing this downwards, stomach brought into view; the greater curvature drawn up to the wound; anterior wall punctured midway between pylorus and cardiac end; canula introduced (so made as to hold the stomach in contact with the abdominal parietes); plug put into canula.	Warm fomentations over abdomen. Eau sucrée and beef-tea injected from time to time; greenish bile accumulated in the stomach, escaped when plug was withdrawn from canula; no pain; patient slept at intervals, and was comfortable during night; in the morning dyspnœa and quickness of breathing; rapid death.	Death fifteen hours after the operation.	Exhaustion. Slight indications of peritonitis.	Sédillot, 'Contributions à la Chirurgie,' t. ii. p. 484.
2	1853	M.	58	Malignant disease of the œsophagus, opposite the larynx: great dysphagia. Symptoms nine months.	A long incision on the left side, two fingers' breadth from the median line, and two centimètres below false ribs; a second incision, perpendicular to this, so as to make a cruciform incision. Stomach seized and fixed to abdominal wall by five or six points of suture carried through its peritoneal and muscular coats only; opening the stomach being postponed until it became united to the parietes. Chloroform given.	Two hours and a quarter after the operation, the stomach was partially torn from its connections by a fit of coughing, and passed into the abdomen; drawn out again, and fixed to the skin by Assalini's forceps. The part thus included became gangrenous, and when removed five days after the operation, the stomach was opened into. The surrounding adhesions were then firm. Through this fistulous opening wine introduced but they would not remain in the stomach.	Death ten days after the operation.	Exhaustion. Peritonitis.	Sédillot, 'Gazette des Hôpitaux,' p. 164, 1853; and op. supra cit. t. ii. p. 494.

				œsophagus from malignant tumour.	through left rectus muscle, along the cartilages of the ribs. Stomach drawn out, opened, and margin of the opening fastened to the parietes.	stomach from the air by means of a bandage, with lint and gutta percha over the wound, and giving nourishing fluids, introduced through glass filter.	eight hours after the operation.	effusion into peritonæum; no peritonitis.	'Archiv. f. Path., Anat. und Physiol.' B. vi. p. 350, 1854.
4	1858	M.	47	Epithelial cancer of the œsophagus; complete obstruction of the canal, and consequent starvation.	Chloroform not given; operation as described in text. The orifice in the stomach was left about large enough to admit end of little finger.	Milk, eggs, and rum, in small quantities, administered every half-hour, through an elastic tube passed into the stomach through the wound; great relief to patient.	Death forty-four hours after the operation.	Exhaustion. Peritonæum healthy; no inflammation nor effusion of lymph or serum.	Cooper Forster, 'Guy's Hospital Reports,' vol. iv. 1858, p. 13.
5	1859	M.	4 yr. 4 m.	Stricture of œsophagus from swallowing a solution of caustic alkali.	Chloroform given; no sickness produced; operation as described in text. Twenty-three weeks after swallowing the poison.	Milk and egg, and egg and wine, given alternately every hour, through a tube passed into the stomach through the wound, with nutritive injections of beef-tea.	Death on the morning of the fourth day after the operation.	Peritonitis following the giving way of the adhesions between stomach and abdominal parietes; caused probably by the slight force employed in introducing the feeding-tube.	Cooper Forster, 'Guy's Hospital Reports,' vol. v. 1859, p. 1.
6	1860	F.	44	Epithelial cancer, involving pharynx and larynx; complete obstruction of the œsophagus, and consequent starvation.	Operation as described in text. Difficulty in securing the cardiac end of the stomach, as it was drawn downwards, and more to the left than usual, by omental adhesion. Four ounces of blood lost during the operation.	Tube, with funnel fitted at the upper end, placed in the stomach through the wound, and retained there until the patient's death. No irritation produced by it. Milk and brandy in small quantities, with small doses of laudanum; nutritive enemata.	Death thirty-six hours after the operation.	Exhaustion. No peritonitis.	Sydney Jones, 'Trans. Pathol. Soc.' vol. xi. p. 101.

Table of Cases—*continued.*

No.	Date.	Sex.	Age.	Nature of Stricture, &c.	Mode of Operation.	After-Treatment.	Result.	Cause of Death.	Operator and Authority.
7	1866	M.	57	Epithelial cancer of œsophagus; passage all but completely occluded: patient sinking rapidly.	Ether spray used; operation as described in text. Scarcely any bleeding.	Subcutaneous injection of morphia; warm milk and water introduced into stomach, but caused much pain. Intensely acid, viscid fluid welled out from the stomach; milk and beef-tea given through catheter every half-hour; great relief; nutrient enemata also administered; no vomiting. Patient gradually sank.	Death thirty-two hours after the operation.	Exhaustion. No peritonitis.	T.B. Curling, 'London Hospital Reports,' vol. iii. p. 218.
8	1866	M.	61	Epithelial cancer of œsophagus, opposite upper border of sternum. Symptoms during five months: extreme dysphagia during ten weeks; liquid food returned, unless taken in very small quantity; the smallest bougie could not be passed.	Ether spray used; operation as described in text. Left lobe of liver exposed, under which the stomach fell, but was easily drawn forwards. Very little hæmorrhage.	Subcutaneous injection of morphia; warm fomentations over abdomen; opening into stomach closed with oiled lint. Quarter-of-a-pint of beef-tea or milk introduced through opening every two hours, alternately with egg and brandy; no pain; patient did well for some days, then symptoms of broncho-pneumonia appeared.	Death on the thirteenth day after the operation.	Broncho-pneumonia. No peritonitis. The edges of the opening into the stomach firmly united to the abdominal parietes.	Sydney Jones, 'Lancet,' vol. ii. 1866, p. 665.

9	1868	M.	70	Epithelial cancer of œsophagus, about three inches below cricoid. Symptoms increasing in severity during some months; starvation impending; smallest bougie would not pass.	Chloroform administered. No sickness produced; operation as described in text. Scarcely any hæmorrhage.	Warm milk introduced into stomach through elastic tube; immediately rejected; a quantity of brownish-green fluid welled up through the opening. Morphia administered subcutaneously. Warm fomentations to abdomen; nutrient enemata of brandy, beef-tea, and arrow-root. Sank suddenly.	Death sixteen hours after the operation.	Exhaustion. No signs of peritonitis. Viscera generally healthy.	A. E. Durham, 'Guy's Hospital Reports,' series iii. vol. xiv. p. 195.

TABLE OF CASES

In which the Operation of Gastrotomy has been performed for the Removal of Foreign Bodies.

No.	Date.	Sex.	Age.	Nature of Foreign Body, &c.	Mode of Operation.	After-Treatment.	Result.	Operator and Authority.
1	1635	M.	—	Knife, six-and-a-half inches in length. Retained about six weeks.	By straight incision through left hypochondrium, two fingers' breadth, under false ribs. Wound joined by five sutures.	Tents impregnated with tepid balsam, and a cataplasm of bolar earth, white of egg, and alum applied.	Wound healed on the fourteenth day after the operation.	Shoval, 'Chelius's Surgery,' Trans. by South, vol. ii. p. 391.
2	About 1743	F.	—	Knife swallowed eleven day previously. First three days no pain; then great suffering.	Incision through abdominal parietes on to knife, which could be felt projecting. The blade had penetrated the stomach, and caused slight suppuration. The knife extracted by forceps.	— —	Rapid recovery.	Hubner. 'Mém. de l'Académie royale de Chirurgie,' 1743, t. i. p. 597. Quoted by Sédillot, op. cit. p. 461.

TABLE OF CASES—*continued.*

No.	Date.	Sex.	Age.	Nature of Foreign Body, &c.	Mode of Operation.	After-Treatment.	Result.	Operator and Authority.
3	—	M.	—	Knife, nine inches in length, swallowed two months previously. Point could be felt towards left end of stomach.	Successful extraction.	— —	Rapid recovery.	Florian Mathis. Recorded by Crollius. Quoted by Sédillot, p. 461.
4	—	—	—	Knife, ten inches long, swallowed six weeks previously. The knife first stuck in the œsophagus, but was forced or washed down into the stomach.	Incision in left hypochondrium. The stomach was hooked forward, and the knife, which could be felt, cut down upon and extracted.	Edges brought together by sutures, and the wound covered up. Restricted diet, vulnerary drinks and balsams; anodyne and emollient injections.	Very rapid recovery.	Schwaben. Quoted by Sédillot, p. 462.
5	1819	F.	24	Silver fork, swallowed eight months previously. During three months gave no pain; then, the position being changed, caused much suffering; rapid wasting of patient. Fork could be felt through the parietes.	Incision through left rectus muscle. The peritoneal surfaces were adherent. Stomach opened, and fork extracted by forceps. No hæmorrhage.	Poultices applied. Some little food escaped through the opening, during the first two days, but not afterwards.	Rapid recovery.	Cayroche, 'Bull. de la Faculté et de la Société de Médecine,' 1819, t. vi. p. 447. Quoted by Sédillot, p. 457.
6	1823	M.	—	Silver teaspoon, swallowed some months previously Could be felt as tumour through abdominal wall.	Swelling cut down upon, and something metallic felt, the opening into stomach was enlarged by bistoury, and the spoon extracted.	Wound healed rapidly. The patient confessed that he had stolen the spoon, and swallowed it for purpose of concealment.	Rapid recovery.	Dr. L. . . . Quoted by Sédillot, op. cit. p. 456.
7	1854	M.	32	Bar of lead, $10\frac{3}{4}$ inches in length, 9 oz. in weight.	Chloroform given. Opening made into abdomen from second false rib to umbilicus. Stomach containing the bar grasped. Opening made and bar ex-	Wound closed by sutures: morphia injections.	Rapid recovery.	Dr. Bell, Iowa. 'Boston Journal,' vol. lxi. p. 489. Quoted in 'Med. Times Gaz.' 1860, p. 332.

It is doubtful whether life was prolonged by the operation in any of the cases of gastrotomy performed on account of disease; but in several the most manifest comfort and relief were obtained.

In every case, so far as I may venture to express an opinion, and notably in the case under my own care, the operation was performed too late, and the powers of the patient were too far exhausted, to afford a fair chance of success.*

The experience hitherto acquired serves, however, to show that the stomach can be reached, opened, and attached to the abdominal walls without difficulty, and that the operation itself is not attended by any immediate danger. Further experience, obtained under more favourable conditions, may not improbably prove more encouraging. It cannot be regarded otherwise than as an opprobrium of surgery, that hopeless starvation should be accepted as the inevitable issue of simple constriction of the gullet.

In preparing the preceding pages free use has been made of the original article by the late Mr. Henry Gray, the general arrangement of which has been preserved. But the whole article has been re-written, and very many and copious additions have been made.

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* See paper by the writer in *Guy's Hospital Reports*, 3rd Series, vol. xiv. p. 195.

ARTHUR E. DURHAM.

INJURIES OF THE CHEST.

FROM time immemorial these injuries have been described under two distinct heads, viz. those affecting the parietes, and those involving the contents, the pleura constituting the limit. Although the distinction is merely artificial, still, for practical purposes, we may adopt it on the present occasion. But before proceeding with our inquiries, let us invite the serious attention of the surgeon to the very great importance of an accurate knowledge of the anatomy of the parietes of the chest, and the organs contained therein; for no one can possibly undertake to make any satisfactory diagnosis or prognosis unless he be well acquainted with the fabric of the walls, and with the relative position and adaptation of the contents, as also with the varied phenomena of inspiration and expiration—not forgetting the actual position of the diaphragm and its extensive encroachment within the domains of the chest, carrying along with it, as it does, many of the important abdominal viscera, such as the liver, stomach, &c., which lie under its expanded and protective walls. Moreover, the surgeon should be thoroughly able to appreciate and detect all normal sounds of the lungs emitted through the parietes, by the aid of percussion and auscultation, as well as the natural sounds of the heart and its valves: for without this knowledge he could not possibly undertake to interpret the abnormal signs and sounds consequent upon disease and injury, such as the crepitation of fracture and that of pneumonia—the dulness on percussion, and absence of respiratory murmur in effusions into the pleura and pericardium—the rubbing sounds of pleurisy and pericarditis, &c.

The arrangement of our subject will be as follows: firstly, wounds and injuries of the surface and parietes of the chest, usually denominated non-penetrating wounds; and this section will include fracture of the ribs, and contusion: secondly, wounds and injuries of the interior and the contents, called penetrating wounds; and to this section will be added the rare complication of injured viscera from contusion, unaccompanied by external breach of surface.

I. Injuries and Wounds of the Parietes.

In considering these lesions, we must bear in mind that the wall of the chest is built up of twelve pairs of more or less movable, semicircular hoops of bone, the ribs, which are attached to the spine behind by strong inextensible ligaments, and in front connected by means of elastic solid substances, the costal cartilages, to a central shield of spongy bone, the sternum;—that these cartilages often become ossified, in advanced age;—that between the ribs there are spaces filled up by muscles; and that there is an artery, vein, and nerve, running close along and under cover of the lower border of each rib, in the upper part of each intercostal space;—that the chest is further protected on its surface by the large and powerful muscles which attach the upper extremity to the trunk;—and lastly, that, from its exposed position, additional security is obtained by the scapulæ and vertebral column behind, by the protective position of the arms depending on either side, by the clavicle, and by the almost instinctive movements of the upper extremity in warding off injury in front.

Contusions of the surface of the chest may be of a simple, uncomplicated character, resembling the ordinary forms of contusion, which have been already described in the preceding volume; but they may also be attended with lesions to structures peculiar to this region, and these will require special notice. Thus, contusions may be complicated with rupture of the superficial and thoracic vessels, which are of considerable size, and pour out blood freely. This effusion of blood may be confined merely to a certain space; but at other times it may be so very extensive, and so rapid, as to excite alarm lest the main trunk has given way. When seen several days after the injury, it is liable to be mistaken for acute suppuration; but the diagnosis will be based upon the sudden and rapid appearance of the swelling after the receipt of the blow, the soft and fluctuating condition of the enlargement, the absence of discoloration of the skin in the first instance, and the absence of any inflammatory action afterwards. Sometimes the effusion may continue so as to cause tension by over-accumulation, but, generally speaking, these cases are by no means serious, provided they be not meddled with; and there are many instances recorded where the whole of the front of the chest on one side has been bathed in an extensive effusion of blood, and which have yet done well, without causing any bad results. The treatment, therefore, will consist in endeavouring, firstly, to arrest any further effusion of blood, thus favouring coagulation, by cold applications and the use of evaporating and saturnine lotions; and, secondly, to promote the absorption of the extravasated blood, when nature's efforts are sluggish and tedious, by the application of stimulating embrocations, care being taken not to carry this to so great an extent as to excite inflammation.

Sometimes contusions are complicated with rupture of some fibres of powerful muscles, such as the pectoral; these accidents, however, are not very frequently met with in civil practice, but are by no means uncommon in military experience from the effects of spent balls, &c. Rupture of a muscle has been likewise observed in cases where the individual has fallen across a projecting body, or whilst falling from a height has grasped a fixed body during his descent. The accident is at once recognised by the total or partial loss of the use of the muscle thus injured, and by the sensible gap existing between the torn fibres. The treatment consists in the relaxation of the muscle and careful approximation of the ruptured ends by position; and this is to be maintained, if necessary, by means of bandages.

Contusions, complicated with *fracture of the ribs*, are injuries of very frequent, almost daily, occurrence, and this must be the case when they form one-ninth or one-tenth part of all fractures; thus, of 2,275 fractures admitted into Guy's Hospital during a given period, there were 222 fractures of the ribs, exclusive of a large number of other cases of such injury, treated as out-patients; and of 2,358 fractures admitted into the Hôtel Dieu at Paris, there were 263 fractures of the ribs. Both sexes are liable, but not equally so, for females are less exposed to injury and accident; thus, of 161 observations at Guy's, 25 were females, being a little more than a sixth; and of 263 observations at Hôtel Dieu, 48 only were females, being nearly a fifth. With regard to the age, the accident is found rarely to occur in the young, in consequence of the great elasticity of the structures; it is more frequently met with in elderly people, when the ribs have become more firm and the costal cartilages more dense, rendering them less capable of resisting shock, in consequence of some loss of elasticity. Of 161 cases admitted into Guy's Hospital, 9 were under 15 years of age, the youngest being but 2 years old; 26 between the ages of 15 and 30, 78 between 30 and 50 years, and 48 above 50 years old, of whom upwards of 4 were over 70:—thus, under 30 years of age there were 35 cases, and over 30 and upwards no less than 126 cases.

The causes must for the most part be referred to external injury, such as blows, falls, the passage of wheels over the chest, pressure between two opposing forces, &c. &c.; but in some very rare instances the ribs have been proved to be fractured from internal causes, viz. during the severe efforts of coughing. In these latter instances, the ribs have generally been found in some morbid condition; and Malgaigne has collected 8 such cases, 4 of which occurred in males and 4 in females; their ages were noticed in 6 cases—5 from the age of 47 to 63, and 1 in a young man—the ribs had given way at the anterior part, near the cartilages. M. Malgaigne remarks, that probably the ribs had undergone atrophic thinning, and that the fractures were the result of muscular efforts.

Respecting the condition of the fracture, the ribs may be broken in one of two ways: either at the seat of injury, by a forcible blow or fall on some projecting body, constituting what are termed direct fractures, and in such cases one or two ribs only are found involved, with the broken ends often driven inwards; or, secondly, the fracture may take place at some distance from the site of the external violence, hence called indirect fractures; here the ribs generally give way about their middle, or most convex part, at the point intermediate between the two opposing forces, as for instance in those cases where the chest is squeezed against a wall or a post, or where the wheel of a cart or vehicle passes over the chest: in such fractures, three or more ribs are involved, and the fractured ends are often driven outwards.

Again, the fracture may be incomplete; that is to say, the ribs are only fissured, or, the periosteum being probably preserved and remaining untorn, no displacement or evidence of the existence of fracture is found. Complete fracture is where the rib has been broken through, either in a vertical or oblique direction, and the two ends readily grate against each other during forced respiration. In general there is no shortening, as met with in fractures in other parts of the body, and this is readily explained by the fact of the ribs being firmly fixed both in front and behind; and again there is little or no vertical displacement, because the intercostal muscles are so placed above and below the injury as to prevent any separation in this direction.

Fractures are generally confined to one side of the chest, but in severe and complicated accidents both sides may be involved; in such cases the injury must always be regarded as of the most serious nature. Sometimes a rib may be broken in two places, or may even be comminuted; these cases are, however, rare.

The middle ribs are the most frequently injured, and least of all the first, second, and third;—thus, of 61 cases recorded at Guy's Hospital during a specified time, there were 44 cases involving the fourth, fifth, sixth, seventh, and eighth ribs; 13 cases with fracture of the last four ribs, and 4 cases in which the first three ribs were injured; the fracture of a single rib was observed in 9 of the cases.

Fracture of the ribs may be uncomplicated or complicated. By the former is meant such fracture as occurs without any external or internal lesion; a mere broken bone without injury to adjacent soft structures. Complicated fractures comprise, firstly, those co-existing with an external wound, analogous to compound fracture of the limbs; secondly, comminuted fractures where the rib or ribs have been broken into small pieces, as observed in gun-shot wounds; thirdly, where the broken rib has pierced the pleura, causing pleurisy, &c.; fourthly, where it has penetrated the tissue of the lung, inducing emphysema, hæmorrhage, pneumonia, &c.; fifthly, where it has injured the pericardium and heart; sixthly, where it has wounded the intercostal vessels; and seventhly, where it has involved the diaphragm and abdominal viscera. All these complications will be referred to under the title of the special injury, such as wounds of the lung, emphysema, &c. &c. The relative proportion of uncomplicated and complicated fractures may be well exemplified by the analysis of 136 cases admitted into Guy's Hospital during five years: 108 were uncomplicated fractures, of which 8 only had secondary inflammation, which proved fatal in 2 instances from previous old-standing disease; 28 were complicated, 16 with emphysema, of whom 4 had symptoms of pneumonia, but all recovered, and of the remaining 12, 6 died at once from fatal collapse, and 6 recovered; of these latter 3 had hæmoptysis and emphysema, and 3 extensive injury and severe inflammatory symptoms.*

The ordinary symptoms and diagnosis of a fractured rib *per se* will consist of, firstly, the sensation expressed by the patient of his having felt something snap or give way: secondly, his complaining of pain at the seat of injury, a kind of severe stitch in the side, or catching of the breath during an irregular respiration, while he carefully avoids to take a deep inspiration or a prolonged expiration; even the slightest attempt to cough distresses the patient and disturbs the fracture, giving rise to the sensation of grating: thirdly, the partial arrest of the movements of the ribs on the affected side, as well as of those on the sound side, in consequence of their consonance of action; hence the respiration is carried on principally by the diaphragm and abdominal muscles: fourthly, the detection of crepitus, owing to the movements of the fractured ends one against the other; and this is to be ascertained by manipulative measures, either by simply placing one hand firmly over the seat of mischief, whilst the other hand is employed in making counter-pressure on the opposite side of the chest, and then instructing the patient to take a full inspiration; or by applying the hands one on either side of the supposed seat of fracture and making alternate pressure, so as to cause the two ends to rub against each other; or in very thin subjects, by taking hold of the rib in front and making the necessary movements; or lastly, should all these means fail, by having recourse to auscultation, which will often assist in detecting the crepitation of fracture, notwithstanding the depreciation of its value in obscure cases by some surgeons of excellent authority. It must be borne in mind, that, although crepitus is an essential indication of fracture, yet in some rare instances it may escape detection, and more especially when one bone only is broken, and at a part where it is thickly covered by muscles or much fat, or where the periosteum has remained untorn: hence caution must be used in denying the existence of fracture in consequence of the absence of crepitus.

The prognosis is in general exceedingly favourable, but of course it will be modified according to the primary and secondary complications, more especially the lesion of important structures. In old and elderly persons, who happen at the time to be the subjects of bronchitis, asthma, or other form of chronic disease, a guarded prognosis must always be given, even should the fracture be uncomplicated; for these individuals often succumb, in the one instance, to shock from their low state of vitality, and in the other to a kind of asphyxia from inability to free the lungs of the accumulated mucous secretion.

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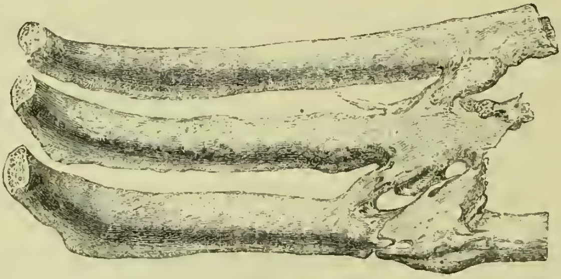
* *Guy's Hospital Reports,* vol. vi. 1860.

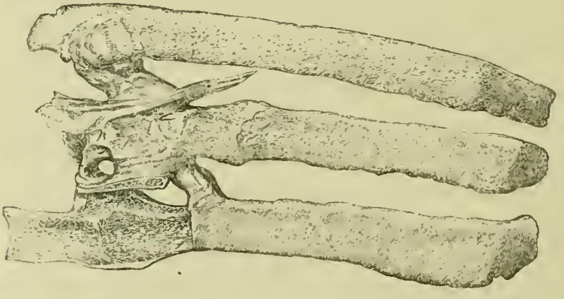
Fig. 81.



External view of a preparation of fractured ribs, repaired and united to each other by extension of callus.

Consolidation of the fractured ends generally takes place in from twenty-five to thirty days. The callus is thrown uniformly out over the whole circumference of both bones, and seldom or ever forms any great projection on the pleural aspect. Sometimes an excess of callus may extend so as to form junctions with the rib above and below.

Fig. 82.



Internal view of the same. Guy's Hospital Museum.

A false joint may arise from deficiency of callus, or from a clot of blood placed between the two ends; but this is not a usual occurrence. Again, callus may be thrown out around each end of the broken rib, and yet the ends themselves not coalesce; this is seen in Prep. 421, in the Museum of the College of Surgeons of England, described thus:—'Part of a first rib, labelled in the handwriting of Mr. Hunter. The extravasated blood has dried and absorbed. The adhesive inflammation in the surrounding parts is forming the union. The broken ends of the rib are in apposition, and an irregular ring of new bone is formed round each of them; but the two rings have not coalesced so as to form a bond of union like a provisional callus encircling the fractured part; neither has any union taken place between the bones themselves.' See also the remarks and figures in the essay on FRACTURE, p. 73.

In the Museum of Guy's Hospital is a very interesting and remarkable skeleton of a rhinoceros, in which almost every rib on either side has been fractured and repaired. It shows in a marked manner the beautiful arrangement of the disposition of the callus. Some of the ribs had been fractured in two places, and it would appear that the animal had been at various times struck with an iron bar by his keeper. The carcase was bought of the proprietors of the Surrey Zoological Gardens many years ago, when the animal had died.

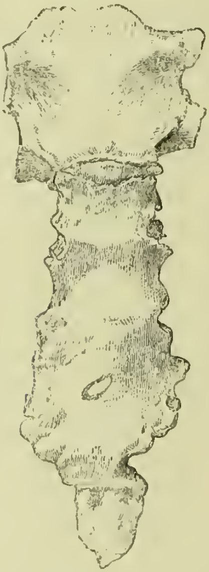
The treatment comprises local and constitutional measures. The local treatment consists in maintaining the ribs in as perfect a state of rest as possible, and this is to be accomplished by rendering them immovable, by any of the following plans: firstly, and this is by far the most preferable, the application of long strips of adhesive plaster, extending from the spine to the sternum of the affected side, and successively applied to some distance both above and below. These possess the advantage not only of not being easily displaced, but of affording a more effectual relief by confining and restraining that side of the chest without affecting or interfering with the free action of the opposite side in the acts of respiration. Some surgeons prefer the use of a large sheet of strapping, instead of the long strips, but its application is not so uniform or so satisfactory. Secondly, the use of a flannel roller, about one hand's breadth and eight to ten yards long, which is made to encircle the chest by several turns and with a moderate degree of tightness. The roller is, however, liable to slip, and requires re-application every second or third day. Some use a broad sheet of linen, which is passed around the chest and fixed either by pins or needle and thread, and there maintained in this position by a kind of braces carried over the shoulders, similar to the double T bandage of the French; others again prefer a simple belt and scapulary, which is merely a mechanical adaptation of this latter. Thirdly, the use of compresses, pieces of pasteboard, splints, &c., which are sometimes required, more especially in those cases where the fractured ends are driven inwards; and the object of the surgeon being to lever out the displaced bones, or at all events to prevent the ends from making further pressure on the internal structures, these splints or compresses are placed vertically on either side of the fracture at some little distance, and maintained there by strapping, when the whole is enclosed by encircling the chest by several turns of a broad flannel or linen roller. Fourthly, the recumbent position in bed has been recommended, and even adopted by some surgeons, instead of local treatment, and without any application whatever: but this plan is rarely adopted, except in those cases where the least pressure or confinement of the chest gives pain and uneasiness. This is the exception rather than the rule, for in the majority of cases the confinement of the movements of the ribs is described as being grateful, giving great relief, and allowing a gentle, easy, and comfortable respiration.

The constitutional treatment will comprise the administration of the ordinary remedies, according to the general principles of surgery; such as rest and quietude for several days, a careful and judicious diet, and abstinence from stimulating drinks. Where much cough and bronchial irritation supervene, expectorants, diaphoreties, and demulcents may be usefully employed. Where there is much dyspnœa, the exhibition of antimony and antiphlogistics is highly important; the antimonial wine being the most effective medicine, to be administered in frequent doses, and varied in quantity, according to the age and powers of the patient. Where there is hæmoptysis or subsequent pleurisy or pneumonia, in addition to these remedies venesection must be had recourse to; but this powerful agent must be judiciously and cautiously wielded. In properly-selected cases it acts as a charm, and often snatches the sufferer from impending death: its chief indications are, the continued and distressing dyspnœa, the oppressed circulation, as evidenced by the labouring pulse, and the strength and powers of the individual. In former years it was too much the fashion to employ the lancet in cases of fractured ribs; but latterly the current of practice has rather flowed towards the opposite extreme, perhaps too much so; however, the surgeon must be entirely guided by circumstances, and meet the difficulties and complications as they arise, by adopting prompt measures, recollecting that the young bear active treatment better than old people. Of the 136 cases already alluded to, as admitted into Guy's Hospital, the majority of the cases, viz. 100, required little or no constitutional treatment, and of the remainder only three required venesection. In appropriate cases of internal inflammation, mercury is invaluable.

Fractures of the sterno-costal cartilages, uncomplicated with other injuries, are exceedingly rare, although recorded as early as the year 1698, by Zwinger, who found this injury when examining a dead body, and in 1805 by Lobstein. Majendie has written a thesis on the subject, wherein he states, that he had seen upwards of five examples in the space of two years. Malgaigne, in his work on fractures, writes, that he had only seen three cases; and that at the Hôtel Dieu, there was only one case in 2,328 cases of fracture generally. He attributes this paucity to the probable omission of this lesion in the hospital returns. The causes of this injury may be, like those of the ribs, direct or indirect. The eighth rib is said to be the one most liable, then those immediately above it: generally speaking, one end overlaps the other, which renders the diagnosis easy, and these ends may become united in that displaced condition by osseous matter without any subsequent ill effects. Delpect remarks: 'If the fracture takes place near the sternum the internal fragment passes in front and crosses the external; the contrary when the fracture is nearest the rib.' Fracture of the cartilage becomes repaired by bony union, ossifying callus; but not always so. In the Museum of St. Bartholomew's Hospital are three specimens: Series iii. No. 4, section of a cartilage of a rib which appears to have been fractured and reunited by the growth of a new cartilaginous substance; No. 48, section of the cartilage of a rib which has been fractured and is firmly united; the uniting medium consists of cartilage and of bone; and No. 73, where the fractured portions are surrounded by a ring of bone.

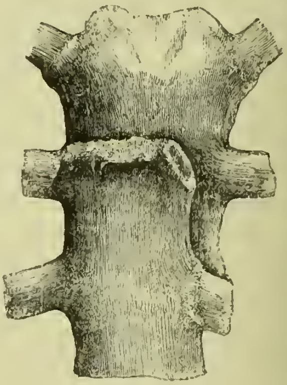
The treatment will be the same as for fractured ribs: some, however, have recommended that, where one end overlaps the other, pressure should be made, so as to restore them to position; but inasmuch as great force must necessarily be used, which may cause injury to the soft parts, and the risk of inducing sloughing of the integuments, this plan is generally deprecated. Malgaigne states that he has used with success a modification of the common truss, furnished with well-protected pads: the one pad is placed on one side of the fracture, the semicircular spring made to encircle the chest, and the counter-pad made to press upon the other end of the fracture. By this means in one case, after twenty days' application, he found the fractured ends *in situ*, and a perfect cure resulted.

Fig. 83.



Fracture of the first bone of the sternum transversely; from a man aged fifty-six, who fell forty feet from a scaffold and died in two-and-a-half hours. He had likewise fractured spine, ribs, and other bones.

Fig. 84.



Fracture of the second bone of the sternum transversely and obliquely; from a man aged forty, who fell off a waggon-load of hay, and was sent up to the hospital from the country, and died on the following day.

(*From preparations in Guy's Hospital Museum.*)

Fracture of the sternum is also by no means common, for during eleven years at the Hôtel-Dieu only one example is recorded; and at the Middlesex Hospital, according to Mr. Lonsdale, two cases were met with in 1,901 fractures. At Guy's Hospital, during five years, two cases occurred, one of which was not detected during life, but was associated with other more severe injuries; one case only was admitted in the year 1843, another in 1845, and another in 1846. It is probable, however, that the rarity of this injury has been exaggerated. Fracture of the sternum alone is, indeed, an extremely uncommon accident; but as a complication of fractures of the spine or ribs, it is much more frequently met with: thus, at St. George's Hospital, during the four years 1857-1860 inclusive, nine cases of fractured sternum were dissected; of these, three were associated with fractured spine, and six with fractured ribs.

These fractures may be either transverse or longitudinal; the transverse are the most common, but are by no means always transverse, in the strict sense of the term; the causes are generally direct external injuries. The fracture is often associated with other severe lesions, such as fractured spine, ribs, skull, &c.; or it may be produced by indirect violence, by the forcible bending of the body backwards in falling across a projecting body, thus snapping the bone or tearing asunder the first and second pieces of the sternum; such cases are quoted by Sabatier,* Rollande,† and Malgaigne.‡ Sometimes the contrary condition will cause it, viz. the forcible flexure of the trunk forwards, and the simultaneous occurrence of a contre-coup, by falling either on the feet or the head. Sometimes, but rarely, it has followed excessive muscular action: Chaussier relates two examples of the kind; both patients were females, of the ages of 24 and 25, and the fracture occurred during the efforts of labour with a first child; at the time of parturition both patients threw back their heads, and rested at times on their arms and heels, bowing up their bodies; there was only slight displacement of the fracture in the one case, and none in the other. This accident was observed by Dr. Faget of Mexico: it happened to a celebrated vaulter, who, whilst bending his body backwards, was endeavouring to raise a heavy weight with his teeth. §

The symptoms are the following: the sensation of a breaking or cracking at the time of the accident; pain at the seat of injury, aggravated by deep inspiration or coughing; the detection of the fracture by manipulation, or else by the overlapping of the bones, if displaced. Sometimes there is no displacement, owing to the fibrous and fascial investment remaining intact: but generally the bones ride over each other, and, in nearly all the recorded cases, it is the inferior fragment which lies in front, and is the most fixed portion; notwithstanding its movement during respiration, being pushed forwards in inspiration, and backwards in expiration, the displacement causes no inconvenience.

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* Sabatier, *Memoir on Fracture of the Sternum,* read at the Institut de France, le 26 Germinal, An VI.

† *Bulletin de Thérapie*, tom. vi.

‡ See also Gurlt, *Handb. d. Lehre v. d. Knochenbrüchen*, 2ter Th. p. 264 et sqq., especially p. 311—' Uebersicht über die Casuistik—105 Fälle.'

§ A similar case is referred to by Gurlt, where the patient recovered.

The diagnosis is generally easy, except where there is much swelling and effusion.

The prognosis is favourable where there is no complication nor other severe injury.

The treatment will be the same as for fractured ribs; sometimes the bandage or strapping cannot be borne, so that the patient must be kept in the recumbent position; sometimes, though rarely, he cannot even bear this, and is only comfortable when in the sitting position, with an inclination of the body forwards, resting the head in front; and in this state some have actually remained for eight days. Where the bones have been much displaced, efforts have been made by some surgeons to reduce the fracture, by placing a cushion under the chest, and throwing the shoulders well back, and pressing, at the same time, on the ribs below, thus causing an increase of the arch, and so bringing the edges of the bones into apposition: many other plans have been devised for the same object, but in general, although the reduction may be perhaps readily effected, the difficulty consists in retaining the ends *in situ*. Respecting the suggestions for the use of a kind of corkscrew, to be screwed into the depressed portion, so as to draw it up, and for the employment of elevators and trepans, all these must be considered as not only useless, but the relics of the old cruel and barbarous surgery.

Longitudinal fractures of the sternum are very rare, so that their occurrence has been denied by many authors.

Two cases are mentioned by Plouquet,* and one by Barrau.† The latter case is quoted by Malgaigne, as follows: a mason, aged 60, fell from a scaffold on some large stones; the fracture was longitudinal, and the right portion depressed about eight to ten lines, the left somewhat overlapping: reduction was effected by drawing the arm to the side, and carrying it backwards, then pressing firmly on the middle of the right sternal ribs, making alternate movements from before backwards, so as to disengage the bones, whilst, at the same time, gentle pressure was made on the left or riding portion, so as to keep it on its own level. After reduction, a compress was applied, and maintained by a firm bandage: the case was successful at the end of six weeks, and no deformity resulted.

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* The two cases of Plouquet are those of Krämer and Mayer.

† Barrau, *Thèse de Strasbourg,* 5 janvier 1815.

Fracture of the sternum may be complicated with other injuries, as has already been partially alluded to. The most ordinary complication of this fracture is its occurrence in cases of fractured spine; but sometimes it may cause injury and inflammation of the pericardium, pleura, lungs, mediastinum, heart, &c. These complications will be alluded to in considering the injuries of those structures.

Dislocations of the ribs.—1. *Costo-vertebral.*—The anatomical arrangements for this important articulation would tend to prove that it would be almost impossible to luxate the head of the rib without fracture of the neighbouring parts, so strong are the ligamentous tissues around. Yet it does appear notwithstanding that luxation has been effected after severe violence. However, in most instances, other complications have existed, generally fracture of the spine and displaced vertebræ. Platner observed that fracture rather than dislocation usually took place, and that the head of the rib could be only dislocated inwards, not easily upwards or downwards, and never outwards, in consequence of the transverse process. Boudet arrived at the same conclusion, as detailed in a memoir on the subject presented to the Académie de Chirurgie; the case of dislocation alluded to by him, however, was clearly proved by Boyer (Mal. Chir. t. x. p. 123) to have been one of fracture of the rib near the spine.

Such cases are too few to make it necessary for me to offer many remarks upon the accident. The causes must necessarily be direct violence over a small amount of surface, so that it is expended upon one or two ribs, thus driving the heads forwards and inwards; the force may also be thrown upon the angle of the rib. The opposing forces must be powerful. The diagnosis is difficult, and must be only conjectural: thus there may be a deep depression, but this does not appear to be always present; and it may be overlooked, for there is great ecchymosis and swelling, with pain; there may be mobility of the rib without crepitation.

Table A, page 568, will elucidate the subject more fully.

The dislocation is generally discovered after death. In two of Kennedy's cases, Nos. 6 and 7, the patients recovered; in the boy, No. 7, the diagnosis was purely conjectural, and may be questioned altogether; and considerable doubts may be raised respecting the other case. However, taking into account the case of Sir A. Cooper, which was distinctly verified some years after, we may fairly accept Dr. Kennedy's case as one of dislocation.

2. *Costo-chondral dislocation* (Table B, page 570) is evidenced by the prominence of the rib in front of its corresponding cartilage. It is a question whether these are not cases of fracture. They are not of much importance, and require the same treatment, reduction and its maintenance, as for fractures.

3. *Chondro-sternal dislocation* (Table C, page 571).—Demarquay remarks that in the four cases there reported, it seemed to be rather a sinking in of the sternum, which had caused the luxation.

This luxation is accompanied with prominence of the cartilage and pain, and may be attended with severe after-symptoms, febrile excitement, and spitting of blood.

4. *Dislocation of cartilages upon each other* (Tables D, E, page 572).—It is a question whether these cases were not fractures. The sixth, seventh, and eighth ordinarily articulate with each other; sometimes the fifth and sixth, as also the eighth and ninth at times.

5. *Dislocation of the bones of the sternum*: the first piece dislocated from the second piece (Table F, page 573). Malgaigne divides these into traumatic and idiopathic luxations. Of the *traumatic* variety, he gives ten cases, all males, and occurring between the ages of eighteen and sixty. The causes were either direct or indirect; the direct causes were the rarest: the sternum receiving a violent blow, and great pressure being exercised at the same time on the first piece, forced this backwards behind the lower portion; the indirect causes were variable—falls from considerable heights, bending of the spine forcibly forwards, so that the two pieces being pressed together, the lower becomes displaced in front of the upper. These rare dislocations are generally due to extreme violence, and associated with other severe injuries. The symptoms of the recorded cases were, local pain, difficult respiration, separation of the pieces, and prominence of the second portion. Of the ten cases five terminated fatally, owing to the complications.

During the past thirty years, at Guy's Hospital several cases of dislocation of this bone have been witnessed; reduction could not be accomplished. Where the lesion was uncomplicated with other injuries, the patient generally recovered without any other inconvenience than the deformity.*

Of the pathological variety, Malgaigne gives three cases only. They possess some degree of interest, and are recorded in his work on dislocations.

The tables on the following pages give a short reference to the recorded cases of these several dislocations.

Contusions of the parietes are sometimes followed by inflammation, suppuration, and the development of tumours; these subjects are treated of elsewhere. In the female the mamma is peculiarly liable to injury, a subject which will be referred to under the head of DISEASES OF THE BREAST. There is one complication, however, which requires special mention in this place; it is that of subpectoral abscess, or diffused suppuration under the pectoral muscles, which is generally the consequence of injury. It is attended with severe constitutional symptoms, but the local signs are very obscure, and give no definite indication of its existence; there is great pain, and general tumefaction in the pectoral region, and no evidence of fluctuation, unless the pus reaches the axilla, when its presence may be detected. Its diagnosis must mainly be based upon the constitutional symptoms, viz. severe constitutional irritation, with febrile disturbance, and unmistakable rigors; these, with marked tumefaction, fully warrant the surgeon in making an exploratory incision through the pectoral muscles, in the direction of their fibres, so as to give an exit to the pus. In the course of ten years the author had occasion to perform this operation on four several occasions, and with satisfactory results. After the matter is evacuated, it is essential to keep the wound open, by the introduction of a tent, or else the muscular fibres will close the opening, and a re-accumulation ensue. The tent is to be replaced once or twice daily, as occasion may require. Tonics and good diet must be administered.

Periostitis, necrosis, and caries of the ribs and sternum, do not require special notice, and the operation of resection of the ribs is described in the essay on EXCISIONS.

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* M. Maisonneuve, in the *Archives générales de Médecine*, 1844, sér. 3, vol. 14, p. 255, has written a most excellent and elaborate memoir on dislocation of the sternum, which is worthy of perusal by those interested in these forms of injury.

TABLE A.—COSTO-VERTEBRAL DISLOCATION.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Post-Mortem Examination.	Reference.
1	M.	Young.	Fell into a pit of clay.	Tumour of size of fist over twelfth dorsal spine. Paralysis of lower extremities.	Died fifteenth day.	Fracture of eleventh vertebra, and of twelfth rib on each side. Luxation of left eleventh rib.	Henkel, 'Gaz. méd.' 1834, p. 137.
2	M.	32	Fell ninety feet.	Immediate death.	Died.	Fourth left rib thrown forwards and inwards. Laceration of pleura and lung; no fracture of rib, but fracture of corresponding transverse process.	Boudet, 'Bull. de la Soc. anat.' 1839, p. 104.
3	M.	—	Part of a roof fell upon his back.	Fracture of spinous process of sixth and seventh dorsal vertebræ. Paralysis and other symptoms of spinal injury.	Died fifteenth day.	Fracture of sixth dorsal vertebra, and sixth, seventh, and eighth ribs on both sides. Two had their heads dislocated.	Alcock, 'Lond. Med. Gaz.' 1839, p. 587.
4	M.	11	Blow from heavy lump of turf.	Tumour over heads of two or three last ribs. Paralysis and retention of urine. Suppuration ensued around seat of injury.	Died sixth day.	Complete dislocation of tenth rib forwards; and partial dislocation of the eleventh rib.	Kennedy, 'Dub. Med. Press,' 1841, vol. v. p. 30.
5	F.	15	Beams from roof of cottage fell upon her, one resting on her back.	Immediate death.	Died.	Dislocation of two last ribs on left side. Fractured skull, &c.	Kennedy, 'Cooper's Dictionary,' vol. i. p. 514.

COSTO-VERTEBRAL DISLOCATION—*continued.*

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Post-Mortem Examination.	Reference.
6	M.	20	Fall through scaffold, a portion falling on him.	Supposed dislocation of two last ribs on left side, downwards and forwards. Stated to have come back to natural position in three weeks.	Uncertain.	— —	Kennedy, 'Dub. Med. Press,' 1841, vol. v. p. 30.
7	M.	17	Fall from top of high tree, striking back on one of projecting roots.	Indentation over two last ribs of right side. He rapidly recovered, and in ten days no depression was felt.	Uncertain.	— —	Kennedy, 'Dub. Med. Press,' 1841, vol. v. p. 30.
8	M.	—	Several years before, was thrown off a horse across a gate, and was treated as for fractured ribs.	Lived some years, and died of fever.	—	Head of seventh rib thrown upon front part of corresponding vertebra, and there anchylosed.	Cooper, 'Dislocations, &c.,' edited by B. B. Cooper, p. 521.
9	M.	44	Fell from a third storey and lived five minutes after admission into hospital.	— —	Died.	Left seventh rib completely dislocated forwards on to the vertebra without fracture. Fractured eighth, ninth, and tenth ribs, with injury to the lungs and diaphragm. Fractured lumbar vertebra. Fractured sternum, and other injuries.	'Post-Mortem Records, Guy's Hospital,' 1864, No. 178, Mr. Birkett.

TABLE B.—COSTO-CHONDRAL DISLOCATION.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
1	M.	48	Attacked with fits of severe coughing.	Luxation of eighth rib, on left side, and of seventh rib on right. Accompanied with hernia of lung between eighth and ninth left ribs, and seventh and eighth right ribs.	—	— —	Chaussier, 'Bull. de la Facult.' 1814, p. 50.
2	M.	—	Thrown from donkey, the animal stepped on his chest—right side.	Separation of fourth rib, displaced backwards and downwards. Became replaced on deep inspiration.	C.	Bandage applied during inspiration, and perfect cure resulted.	Bouisson, 'Cooper's Dictionary.'
3	M.	—	Thrown from horse, striking chest against corner of mile-stone.	Luxation of fifth left rib, which was driven inwards.	C.	Replaced readily by strong dilatation of chest. Bandages. Recovery.	De Kimpe, 'Annales de la Chir.' t. ix. p. 316.
4	—	—	Pressed between a post and a carriage.	The majority of the ribs luxated upon their cartilages.	—	— —	Charles Bell, 'Surg. Obs.' p. 171.

TABLE C.—CHONDRO-STERNAL DISLOCATION.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
1	M.	Young.	Exercising with dumb-bells,—violent extension of arms.	Felt something give way suddenly; one of the costal cartilages found luxated forwards on to the sternum.	C.	Replaced by pressure with fingers, and retained by compress and bandages.	Sir C. Bell.
2	F.	72	Fell down during intoxication.	Luxation of fourth left cartilage.	C.	— —	Ravaton.
3	—	—	— —	Cartilages of fourth, fifth, and sixth true ribs luxated in front.	C.	Reduced by pillows behind back, and arching the spine.	Manzotti, 1790.
4	—	—	— —	Luxation of a true rib in front of sternum.	Uncertain.	— —	Monteggia.
5	Baker's boy.	—	Constant action of pectorals in kneading bread, and defective constitution.	Luxation of cartilages of fifth and sixth ribs.	Uncertain.	Advised to desist from employment.	Cooper 'On Dislocation,' edited by B. B. Cooper, p. 447.

TABLE D.—LUXATION OF CARTILAGES ONE UPON THE OTHER.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
1	M.	70	Fell backward off a chair, and tried to regain his position.	Painful cracking of chest. Swelling over three last true ribs of right side; elevation of ribs so that hand could be passed readily beneath them.	—	— —	Martin de Bordeaux, 'Journ. de Vandermonde,' 1780, t. liv. p. 328.
2	—	—	— —	Similar case under similar circumstances. Inferior cartilage luxated behind; sixth, seventh, and eighth ribs displaced.	—	— —	Boyer.
3	—	—	Violent effort.	Seventh, eighth, and ninth ribs displaced from their articulation with each other.	—	— —	Malgaigne, 'Traité des Fract.' t. ii. p. 398.

TABLE E.—ENSIFORM CARTILAGE.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
1	M.	18	Cartilage driven in by blow on epigastrium.	Frequent vomiting, continued until reduction was effected.	C.	Reduction by pressing the fingers beneath it, and elevating it into its place.	Martin, 'Histoire de l'Acad. des Sciences,' 1737, p. 48.
2	M.	19	Fell upon the seat of a boat, and struck his epigastrium.	Violent dyspnœa and vomiting, with pains in stomach; he was for twenty-five days unable to swallow fluids without rejecting. Death imminent.	C.	Incision made on one side of the depressed cartilage, extending through the peritonæum; an instrument passed beneath, and cartilage raised into its place. Immediate relief.	'Journ. général de Méd.' t. xxii. p. 263, 1804.

TABLE F.—DISLOCATION OF THE BONES OF THE STERNUM.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
1	M.	27	Fell forty feet on to pavement.	Dislocation of first piece behind the body of sternum. Fractured cartilage of third rib. Fractured left clavicle and fourth dorsal vertebra. Paraplegia.	D.	Lived six weeks.	Maisonneuve, 'Archiv. gén. de Méd.' 1842, t. xiv. p. 255.
2	M.	42	Fell forty-two feet on to pavement.	Second piece thrown in front of first. Fractured sacrum, disjunction of left sacro-iliac joint. Fractured vertebræ and ruptured bladder.	D.	Expired in short time.	Do. Do.
3	M.	48	Fall from height on back.	Second piece in front of first. Fractured fifth cervical vertebra. Paraplegia.	D.	Died on fifth day.	Do. Do. Mamoury and Thore's case.
4	M.	Adult.	— —	Luxation of first from second; the latter in front of upper. Fractured left clavicle and scapula.	D.	— —	Do. Do. Musée Dupuytren.
5	M.	—	Fall from a ladder, one of the bars struck his chest.	Luxation of first and second pieces.	C.	Replaced dislocation by placing a cushion across back and arching the body over it; maintained by bandages for twenty days.	Do. Do. Auran's case.
6	M.	23	Fell into a cavern, and chest compressed by pieces of wood.	Luxation of first and second pieces.	—	— —	Malgaigne 'On Fractures and Dislocations.'

DISLOCATION OF THE BONES OF THE STERNUM—*continued.*

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
7	M.	60	Thrown into ditch, thirty feet, and fell against large stone.	At seat of union of first and second pieces, separation by fracture, and lower portion thrust under the upper.	D.	Lived eight days.	Maisonneuve, quoted from Sabatier.
8	M.	28	Fell fifty feet on to a wall, back being bent across it.	Separation of first and second pieces. Fracture of two last dorsal vertebræ and femur.	C.	— —	Do. Do. Case of Auran and David.
9	M.	—	Passing from one boat to another; fell and struck upper part of sternum against angular border of boat.	Dislocation of first and second pieces.	—	— —	Malgaigne, 'case at Hôpit. St.-Antoine.'
10	M.	—	Indirect cause was lying on side when enormous stone fell on chest, compressing it laterally.	Second piece projected in front of first, and with such force as to cause a wound.	—	— —	Malgaigne, Duvernay's case.
11	M.	—	Fell from first floor. Body flexed forwards.	Dislocation of first and second pieces with fracture of cartilage of left second rib.	—	— —	Do. Do. Chevaner's case.
12	—	—	Muscular action.	Separation, with fracture of sternum, first and second pieces.	—	— —	Malgaigne.
13	M.	25	Not stated.	Second piece dislocated and thrown forwards on first. Fractured vertebræ.	D.	Lived two weeks, and died from effects of spinal injury.	'Post-Mortem Records, Guy's Hosp.,' 1827. Prep. Museum, 1043.[30]

DISLOCATION OF THE BONES OF THE STERNUM—*continued.*

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
14	M.	25	Struck on chest by a projecting part of an express train.	Dislocation of first and second pieces; the two first ribs remained attached to the upper portion. The lower part was thrown in front of the upper.	C.	Placed in a recumbent position with two bolsters under the back, and at the end of three days, bones resumed their natural position. Entire recovery.	Dumarquay, 'L'Union,' 1868, No. 47.

TABLE G.—PATHOLOGICAL LUXATION OF BONES OF STERNUM.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, &c.	Reference.
1	M. Student in Medicine.	23	Had pain in sternum, causing him to make constant pressure. Osteocopic pains.	Disjunction of the first and second pieces ensued; a false movable joint formed, and subluxation.	—	Arthritic relaxation of joint—query, venereal?—Anti-venereals gave no relief.	Beauchène, 'Journ. général de Méd.' t. xxxiii. p. 287.
2	M. Mechanic.	Adult.	Employed in early youth at watchmaking and short-sighted—constant bending.	Gradual gliding of first piece in front of second—subluxation.	C.	Readily reduced; could subluxate it voluntarily. Cured by avoiding the bending position.	Malgaigne 'On Dislocation,' case of Martin.
3	M. Student in Medicine.	19	— —	Could push backwards with the hand the body of the sternum and its corresponding ribs to extent of two inches, so as to leave a hollow at anterior part of thorax.	—	Often had severe inflammation of the chest.	Dr. Graves of Dublin, 'Lond. Med. and Surg. Journ.' 1835, vol. vii. part 2, p. 577.

Wounds of the parietes of the chest, commonly called non-penetrating wounds, include the several varieties of incised, punctured, lacerated, and gun-shot wounds; the general characters of which are described in the essays on WOUNDS and GUN-SHOT WOUNDS. Here we shall merely refer to certain special complications of the ordinary incised, punctured, and lacerated wounds, as they affect the surface and tissues of the chest. In the first place, the surgeon is always anxious to decide whether the wound be superficial or penetrating:—are there any signs sufficiently well marked to indicate that the wound has not penetrated the chest? This question will be more appropriately considered when alluding to penetrating wounds, for it will be found that the only reliable signs are those of a negative character, viz. the absence of all the symptoms indicating a penetrating wound.

Wounds involving the skin and cellular tissue of the chest require no comment, otherwise than in the punctured variety; where there may be a long track traversed by the weapon, which may give rise to the formation of sinuses and local abscesses, and be difficult to manage in consequence of the movements of the upper extremity and the acts of respiration.

M. Vidal* remarks that punctured wounds, even of the slightest character, may be attended with symptoms simulating those of lesion of some internal organ or internal hæmorrhage; such as coldness of the skin, feeble circulation, a sense of suffocation, syncope, and cough. These phenomena, he states, are chiefly observed in wounds received in duels. Whatever may be the courage of the champion, at the moment of combat the blood does not circulate normally, and the innervation is not regular, and he is not without emotion; if to this moral state there is superadded a wound of the chest, the wounded person regards it with most vivid uneasiness, and if fear has not already set in, it will soon take place. Thus is readily explained the occurrence of the above phenomena, and the salutary effect of removing these impressions by moral agencies of a reassuring kind.

Wounds of the muscles in front and behind the chest, when passing across their fibres, are attended with very great separation, and leave a large gap, in consequence of the power and extent of the individual muscle involved. And in the treatment of such wounds, the function of the divided muscle must be borne in mind, so that the edges may be approximated as closely as possible; thus, in wounds of the muscles in front of the chest, the arm must be drawn forwards, and carried inwards towards the opposite, and maintained in this position during the healing of the wound: in wounds of the muscles behind, the opposite course is to be pursued. In a case of extensive wound of the latissimus dorsi muscle, and in a case of wound of the pectoralis major, M. Petit applied several points of suture, and with success: but sutures through muscular tissue are in general not advisable, unless there be a very large flap; and when employed, they should include the fascia in front of and behind the muscle, else the suture will tear away. Transverse wounds of the intercostal muscles weaken the chest, and sometimes permit the escape of the lung, to which we shall refer further on.

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* Vidal de Cassis, *Traité de Pathologie externe*, tom. iv. p. 66

Wounds of the thoracic and other parietal vessels (excluding the intercostal and internal mammary) partake of the ordinary characters of wounded vessels: the only peculiarity in respect to the chest is in reference to punctured wounds, as in stabs by a sword, bayonet, foil, &c., where a vessel has been involved, and the blood, not being able to escape externally, has diffused itself under the muscles in the loose cellular tissue, and sometimes to a very great extent. This extravasation may coagulate and further effusion cease, when subsequent absorption ensues, with speedy recovery: on the other hand, it may excite inflammation, suppuration, and sloughing. Ice, or carefully applied compression, will be sufficient to arrest the hæmorrhage, if not of very considerable extent; but where one of the larger trunks, such as the vessels of the axilla, has been injured, the case must be treated according to the rules laid down in the essay on WOUNDS OF ARTERIES.

Wounds involving the ribs, costal cartilages, or sternum, require immediate closure of the wound, and the ordinary treatment for fractured ribs. Here, however, we must be on our guard, and ascertain whether or not a portion of the weapon or instrument has been broken off and become imbedded in the rib, or cartilage; an event which has happened once or twice. In general the piece is loose, and readily removed, but in some instances it has been found fixed, requiring immense force to extract it; or it may be smooth and convex on its surface, such as a bullet, when difficulty is experienced in laying hold of it. Sometimes the pointed instrument may traverse the rib and appear on its inner side, causing a penetrating wound of the chest: this we shall refer to again.

Non-penetrating wounds may be attended with emphysema; thus, in wounds traversing the soft parts obliquely and gliding under the large muscles of the chest into the subjacent loose cellular tissue, the air from without may enter into the wound, being drawn in by the movements of the ribs; and this air, not being able again to escape, during expiration becomes diffused, causing emphysema, which may occupy a very extensive surface. A great deal of this air may be pressed out through the wound, but in so doing, care must be taken to close the wound at each inspiration, so as to prevent fresh air being drawn in.

II. INJURIES AND WOUNDS OF THE CONTENTS OF THE CHEST.

These will be treated of under two separate heads: first, those produced by external wounds, commonly called penetrating; and second, those caused by contusion, without any breach of the external surface.

Respecting penetrating wounds, these will be best considered by studying them according to the organ or structure involved, in the following order. 1. Wounds of the pleura and lungs, with their attendant complications; 2. Wounds of the mediastina, pericardium, and heart; 3. Wounds of the intercostal, internal mammary, and large vessels of the chest; 4. Wounds of the œsophagus.

1. *Wounds of the pleura and lung, and their complications.*—In the first place, there may be a simple penetrating wound of the pleura, without injury to any other structure. This accident is exceedingly rare, and to the anatomist might appear scarcely possible, in consequence of the close adaptation of the lung and its pleural covering to the wall of the chest and its pleura; there are, however, sufficient facts proving that this injury does now and then take place, more especially in incised wounds; although its recognition is very difficult. Where the wound is large and the lung distinctly visible, and air is freely drawn in and expelled from the pleural cavity during respiration, the nature of the injury is palpable enough; but these wounds in general are not so extensive, owing to the protection of the ribs; hence we must rely upon other diagnostic marks. And here we are again baffled, because the chief signs are entirely of a negative character, viz., the absence of all the varied indications of a wound of the thoracic contents. The following means have been proposed to assist in the diagnosis: 1st. Deductions drawn from the weapon used, with its attending external circum-

stances; these will comprise the consideration of the varied forms of penetrating instruments, the extent of the blood-stain upon the blade, the size of the wound compared with the breadth of the blade, the respective positions of the injured person and the aggressor at the time of the infliction of the wound, the mode and direction in which the weapon was thrust, &c. These points are by no means decisive, and are often doubtful; for the blade may have two cutting edges, and then the wound will be larger; the bayonet or sword-thrust may glance off the ribs and pass a long distance under the skin, without entering the chest—thus cases are related in which a sword has passed from the right to the left of the chest without penetrating the cavity; again, the position of the combatants is often inaccurately stated. 2nd. Exploration by means of the finger, probe, sound, or other instruments. Were this to be permitted, and a careful and minute examination made by the introduction of the finger into the wound, an easy diagnosis would at once be realised: but in wounds of the chest, as in wounds of the abdomen, all manipulative examination is to be denounced as perfectly unwarrantable, being attended with highly dangerous results, by disturbing nature's efforts to effect a repair, disarranging the clot, and exciting irritation and inflammation; a proceeding tending only to gratify curiosity, without the slightest benefit to the patient. The same remarks apply to the injecting of fluids into the wound, which is to be considered as a relic of barber-surgery, and is wisely expunged from all modern works. 3rd. Another mischievous and meddlesome proposition is the following, viz., the closing of the external wound, and then directing the patient to take a deep inspiration, when he is to hold his breath so as to close his glottis; and then to make an effort to expire, at the same time that the surgeon re-opens the wound and holds a lighted candle close to it: should the wound have penetrated the lung, air will be driven out through the opening and blow the flame of the candle to one side. This must always be regarded as a dangerous and hazardous experiment; and even if justifiable, it is not conclusive evidence, for in many cases of penetrating wounds of the lungs, there are several circumstances which may prevent the escape of air from the organ. 4th. The absence of emphysema is no indication that the lung has not been wounded; emphysema, although a usual symptom of injured lung, may occur even in non-penetrating wounds, as has been already mentioned; it may also take place in wounds penetrating the pleural cavity only: thus air may be drawn in through the external wound during inspiration, and on expiration this air, not finding a ready exit, may be expelled into the neighbouring cellular tissue; or if the incised wound be very large, the air will enter the cavity in a large volume, and should it be unable to escape, it will cause a pneumo-thorax. 5th. The absence of hæmoptysis is by no means a sufficient test that the pleural cavity only has been penetrated. Hæmoptysis, although usually a symptom of injured lung, may take place in non-penetrating wounds, and even in injuries of the lung it may be absent; hence the surgeon must be very cautious in relying upon individual symptoms.

Thus, then, there are no absolute signs upon which we can decide; we must await the issue, and maintain a strict watch for any symptom or complication which may set in; our prognosis must be guarded, and must always be considered unfavourable for at least four or five days, before the patient can be pronounced to be out of danger; and in expressing any opinion, it must be recollected that the surgeon is not bound to state whether a wound has penetrated the chest or not.

The primary complications which may ensue in this class of injuries are, emphysema, pneumo-thorax, hernia of the lung, hæmo-thorax, and the presence of foreign bodies in the wound or cavity. The secondary, or subsequent, complications are, pleurisy, hydro-thorax, empyema, fistulous openings, contraction of the side of the chest, &c. These will be alluded to in their appropriate place.

The treatment will differ but little from that laid down in non-penetrating wounds, viz. the removal of foreign bodies, the arrest of hæmorrhage, the immediate closure of the external wound, and strictly enforcing the recumbent position until the period of danger has passed over. The patient must be kept on low diet, and be carefully watched in the interim, and the slightest indication of any untoward symptom is to be treated with energy, according to the instructions given further on.

A curious complication of a penetrating wound without lesion of a viscus is the escape of an uninjured lung through the aperture, constituting a hernia of the lung, or *pneumocele*. There are two varieties, both of which are comparatively rare; the one occurring at the time of the infliction of the wound, and called immediate, the other taking place after cicatrisation of the external wound, and called consecutive.

The immediate variety is seldom observed, for in general the escape of the lung is difficult, owing to the tendency of the external air to find its way in through the wound during respiration, and thus prevent any protrusion by pressing the lung away from the wound; the hernia, therefore, must take place before the air has time to enter the chest; and the following explanation of its production has been offered. If there be a large wound, and the chest be at the time suddenly contracted with direct closure of the glottis, the air in the lung, not being able to escape by the trachea, becomes pent up in the air-cells, distending and forcing the organ against the parietes, and causing its escape where the latter are deficient. The most frequent situation in which wounds are liable to be followed by hernia of the lung, appears to be at the anterior part of the chest, on a level with the nipple; and this is said to be due to the greater mobility of the lungs in this region, the rarity of any adhesions, and the nearer approach of the wound to the free edge of the lungs, which would more readily find exit. The size of the hernia varies from that of a small marble to that of a cricket-ball, and it forms a more or less globular mass, consisting of the lung-tissue, covered by its own pleura, and having no investing sac; its base is constricted, and encircled by a kind of neck, formed of the external wounded integument and the tissues in the intercostal space. The protruded lung may be at first simply congested; but this congestion may increase to such an extent that the lung may assume a very deep black colour, without, however, any loss of vitality; but when the constriction continues, and the congestion and exudation increase, together with long exposure, gangrene will ensue, and sloughing-off of the whole mass take place, constituting a natural cure. The prognosis of these cases is generally favourable. The treatment will depend chiefly on the state of the lung, and the length of time which has elapsed since its prolapse: if the prolapse be recent, and the lung healthy in appearance, it may be reduced by careful and moderate manipulation, care being taken not to injure its delicate structure in so doing; should, however, this be impracticable, owing to the very great constriction of the neck, the latter, provided it be formed entirely of soft structures, may be cautiously divided, care being taken to avoid wounding the lung or the intercostal vessels. If the lung be in a gangrenous condition, it may be left to nature to throw it off by sloughing; or it may be surrounded by a ligature, and tied; or it may be excised, in order to expedite matters:—all these measures have been severally and successfully tried. Thus, Rollande cut the prolapse off, and powdered the surface with astringents, and with success:—Tulpius tied the pedicle, and excised the remainder; the patient recovered in fifteen days, having had only a slight cough, and died six years after, when, on examination, the lung was found adhering to the pleura, at the seat of injury, but without notable alteration in its structure:—Fabricius relates a case, in which the hernia was cauterized with the hot iron, and a recovery effected, the patient living many years:—Ruysch details a case in which a ligature was applied, and the mass allowed to slough off, and with favourable results. These instances are introduced here as showing how a delicate organ, like the lung, may resist such measures, and not as examples for pursuing the same line of treatment, which is too hazardous, risking the production of pneumonia, and other serious mischief. It is certainly more rational and harmless to leave the hernia alone, under all circumstances, where we are unable to reduce it.

Mr. S. Cooper (*First Lines of Surgery* p. 460) mentions a case brought to him at Brussels after the battle of Waterloo. The protruded piece of lung was of a long, narrow, tongue-like form, and severely contused. The wound had been made with a lance. He thought at first of cutting the protrusion off, but the bleeding made the inclusion of it in a ligature necessary. The patient, he believed, did not ultimately recover.

An immediate hernia of the lung may occur without any external wound, as observed in rare cases of extensive comminuted fracture of the ribs; here the lung is generally injured, and the lesion itself is so severe as to be attended with almost immediately fatal results. It has also been described as having taken place during violent straining in the efforts of parturition.

The consecutive variety is when the protrusion takes place after the external wound has closed: thus Velpeau records the case of a man, aged 29, who received a sword-thrust at the inner side of, and a little below, the left nipple; he lost much blood, but had no hæmoptysis; the wound healed in six weeks, and in three months and a half after the injury he was admitted into the hospital with prolapse of the lung; the latter was found fixed in its present position, and was therefore left alone. In this class of cases the lung is covered by integument; the development and progress of the protrusion is very slow, and it may sometimes attain a considerable size. The signs of this occurrence will be, the appearance of a soft tumour, which is more or less circumscribed, elastic, and indolent; the integuments covering it are perfectly natural, and without any change of colour. The swelling moves simultaneously with respiration, expanding in expiration and diminishing in inspiration; it enlarges equally at all points during coughing; and if respiration be suspended for some time, the tumour disappears. On manipulation it crepitates and imparts an impulse on coughing, and the depression in the parietes can be readily felt. On auscultation, it emits numerous vesicular bruits; the respiratory murmur is normal, but is louder and less mellow than in the natural situations.

The treatment will consist in protecting this hernia from external injury, and in preventing the further protrusion of the viscus: this may be done by means of carefully-adjusted pads and bandages: some have recommended the application of a hollow-padded truss, to be made on the same principle as that of the umbilical truss.

Congenital and spontaneous hernia of the lung are exceedingly rare; these varieties do not come under our consideration in this work.

A wound of the lung may be superficial or deep; and when arising from external wound, it may be either of the incised, punctured, lacerated, or gun-shot variety; but when produced by fractured ribs, it is generally of the lacerated kind. The incised wounds are the most dangerous, as they almost always give rise to immediate hæmorrhage and escape of air; the lacerated wounds are next in severity, on account of the retractility of the lung-tissue; punctured wounds, such as are caused by a stab, are the simplest form, and offer a more favourable prognosis;—gun-shot wounds have been specially considered in a previous essay (see p. 191).

Three conditions generally take place when the lung is wounded—the escape of blood or hæmorrhage, the escape of air from division of the air-vesicles or tubes, and a more or less collapsed state of the organ. The escape of blood may take place into the parenchyma of the lung, causing ecchymosis, or a kind of pulmonary apoplexy, and this is generally met with in superficial wounds, and in the punctured variety; it may escape into the air-tube, and be coughed up with the sputa, constituting hæmoptysis; it may pass through the parietal wound externally; or it may flow freely into the cavity of the pleura, producing hæmo-thorax. The escape of air may likewise find its way into each of the above situations, viz., into the lung-tissue, causing lobular emphysema, as observed in punctured wounds; into the bronchi, mixing with the blood and sputa, and forming a mixture of a frothy red character; into the pleural cavity, inducing a pneumo-thorax; or it may escape externally through the parietal wound, but more generally it becomes diffused into the subcutaneous cellular tissue, producing more or less extensive emphysema. The collapse of the lung may or may not take place, and this will depend a good deal upon the antecedent circumstances: where a lung has become adherent from old pleuritic adhesions, no collapse will ensue, nor any escape of air or blood into the pleura; hence a favourable issue will be expected.

The repair of a wounded lung may take place in a few days; slight inflammation and exudation of plastic material ensues, causing a partial hepatisation, then organisation of the thin plastic effusion, when contraction and cicatrisation follow; all of which may be completed in from ten to fifteen days. In a few rare instances, immediate union has been proved to have taken place.

The symptoms diagnostic of a wounded lung, excluding the primary and secondary complications (viz. emphysema, pneumo-thorax, hæmo-thorax, pleurisy, pneumonia, &c.), are the following:—1. The escape of blood and air through the external wound, of a pale red and frothy character; this symptom will be a strong presumptive evidence, but its absence by no means indicates that the lung is not wounded: there may be an influx and efflux of this frothy blood during inspiration and expiration, should the wound in the lung be opposed to the external one. 2. The issue of blood mixed with air and mucus from the mouth during the efforts of coughing; and this is always to be regarded as a dangerous sign, for bleeding is generally abundant in severe wounds of the lung, and in such wounds, the complete expulsion of the blood being impossible, it accumulates in the tubes, producing a choking sensation, and may suffocate the patient. 3. A deeply fixed pain in the chest, and a considerable degree of irritation and tickling in the larynx, inducing a constant desire to cough. 4. Dyspnœa and difficulty in respiration, owing to partial collapse of the lung, or pressure upon its structure.

The constitutional symptoms are, in the first instance on receipt of the injury, those of collapse, arising either from shock or great loss of blood: this symptom need not excite alarm, unless it extend over a protracted period. After a short time reaction ensues, and to this condition the surgeon directs his chief attention: inflammation and inflammatory fever, pleurisy and pneumonia, are next to be apprehended, and to be warded off if possible: the symptoms and treatment of these complications do not come within the province of this work.

The prognosis of wounded lung must generally be regarded as unfavourable, even when unattended by any dangerous complication.

The local treatment will consist in arresting any hæmorrhage from the superficial vessels, in removing all extraneous bodies, and in closing the external wound as quickly as possible, so as to prevent air being drawn into the chest; and then confining the chest to a state of repose by carefully-applied strips of adhesive plaster, extending from the spine to the sternum. The external application of ice to the chest has been used in severe hæmoptysis, and with the best effects. The constitutional measures will comprise the adoption of such remedies as are appropriate for the particular stage in which the patient is found: thus in the stage of collapse it is not desirable to interfere, for collapse is the means by which hæmorrhage is restrained, by allowing coagulation to take place in the divided vessels. The patient should be left in the position in which he is found, or be carefully carried to some more convenient locality; the room or place should be cool, and every measure tending to prevent hæmorrhage should be adopted. In the stage of reaction much energy, discretion, and sound judgment must be displayed by the surgeon, and his attention must be mainly directed to the degree and severity of the hæmoptysis, dyspnœa, and thoracic complications: total abstinence from food and exciting drinks must be enjoined for the first few days; the internal exhibition of ice and cold diluents is acceptable; the judicious and prompt use of the lancet will cut short a severe hæmoptysis, and will tend to prevent the subsequent development of inflammation. Venesection should be performed in the semi-erect posture, and the blood taken *pleno rivo*; and we should bear in mind that the object of the venesection is not so much to take away blood as to make a sudden impression on the general system, so as to induce an artificial collapse. Dr. Macleod remarked that the cases of gun-shot wounds of the lungs, in the Crimean campaign, which did best, were those in which early active and repeated bleedings were had recourse to. The employment of the remedies prescribed in case of hæmoptysis may be used with effect, such as sulphuric acid, in large doses, acetate of lead, &c. In the stage of inflammation, the treatment will comprise the adoption of the measures detailed in works on the practice of medicine, under the headings pleurisy, pneumonia, &c. &c.

The following complications, although generally associated with wounds of the lung, may occur from other causes. We have had occasion to mention these complications incidentally, but shall now describe each separately.

a. Emphysema, or the infiltration of air into the subcutaneous cellular tissue, when occurring in the region of the chest, may be due to one of four conditions: the first, and by far the most frequent form arises from fracture of the ribs, where the broken bone has penetrated the pleura and entered the lung, allowing air to escape: the second, from penetrating wounds of the lungs or bronchi; where on inspiration the air received into the lung escapes from its wounded part into the chest, and on expiration is forced out through the external wound, diffusing itself in the cellular tissue; if the external opening be large and directly corresponding to that in the lung, no emphysema may take place, but in oblique and punctured wounds it is almost always present, and increases during every successive act of respiration: the third, from penetrating wounds of the pleura without any lesion of the lung, where the air enters from the exterior during each inspiration, and on being forced out again at expiration, cannot entirely escape, but diffuses itself under the integument: the fourth, and rarer form proceeds from rupture of the air-cells without any external wound or fracture; this latter is generally found occurring in idiopathic emphysema, and arising from pathological causes, such as the bursting of a vomica; but it may be observed in traumatic cases, as from violent efforts while holding the breath in parturition, and in the rare instances of rupture of the lung from external violence without fracture or wound: and we may here include those cases in which the air makes its way into the posterior mediastinum, travelling up through the superior opening of the chest into the cellular tissue of the neck, and then diffusing itself through the body.

The symptoms of emphysema consist of a swelling of the integument, commencing at the seat of mischief, and gradually and progressively increasing in all directions, the skin remaining of a perfectly natural colour; this swelling has a peculiar and distinctive character, which renders its diagnosis easy, viz. a crepitating and crackling feel under pressure, by some compared to the feeling of a dry bladder half-filled with air—it is elastic, but the air may be made to change its situation by digital pressure; it speedily returns, however, on removal of the finger, and is thus unlike œdema and anasarca, which pit on pressure, and remain so for some time: there is no attending pain. In some cases, where the wound of the lung has been very large, it may extend from head to foot in an incredibly short time; the patient being, as it were, blown out to an enormous size. The constitutional symptoms will depend upon the pressure exerted by this diffused air upon important organs, such as the trachea; its diffusion into the mediastinum and into the pleural cavity; when the patient will complain of tightness of breathing, followed by increased difficulty, which will become almost insupportable, so that he cannot lie down: impeded aeration of the blood and obstruction to the circulation soon show themselves, by the livid red, swollen, and suffused countenance, the weak, contracted, and afterwards irregular pulse, cold extremities, and, if this condition be not relieved, death by suffocation.

The prognosis is in general very favourable, except in cases of extensive wounds.

The local treatment will in some measure depend upon the nature of the cause: thus in emphysema from fractured ribs, a question arises whether or not a bandage or strapping should be applied.

Abernethy* speaks in favour of this practice: 'Pressure by bandage not only hinders the air from diffusing itself through the cellular substance, but serves to prevent it from escaping out of the wounded lung, and of course facilitates the healing of the wound, which would be prevented by the constant transmission of air. Its early application, therefore, will often prevent a very troublesome symptom, whilst at the same time, by keeping the fractured bones from motion, it greatly lessens the sufferings of the patient.' Samuel Cooper,† on the other hand, remarks: 'When emphysema is complicated with a fractured rib, the latter injury is unquestionably a reason in favour of a bandage. But whether the pressure of the roller will be useful or hurtful with respect to the emphysema itself, or the state of lungs and respiration, may be questionable. As for its tendency to resist the diffusion of air in the cellular tissue, this circumstance does not appear to me important, because the air thus diffused, much as it disfigures the patient, is nearly harmless, at least so long as the great serous cavities and the interlobular texture of the lungs remain uninflated; a danger, also, which no bandaging has any tendency to prevent. Neither will a bandage have so much effect in hindering the diffusion of air as scarifications, with this important additional consideration, that punctures, or small incisions made over the broken rib, prevent the spreading of the air, by letting it escape, while a bandage can only do so by more or less resisting its escape from the cavity of the pleura, which mode of operation in some cases would dangerously interfere with the continuation of respiration by the lung of the opposite side.'

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* *Surgical Works,* vol. ii. p. 179.

† *Surgical Dictionary,* 7th edit. p. 489.

It appears best to be guided in this respect by the patient's sensations. If moderately firm pressure on the injured part of the chest with the hands affords relief to the breathing, it will be right to make trial of the bandage; but if this appears to increase the pain or the dyspnœa, its use must be abandoned. Some surgeons are great advocates for making punctures, or small incisions, in emphysema; but in general they are not requisite, and should form the exception rather than the rule, to be employed when the air has diffused itself over a great extent of surface, and not to be performed over the fractured bone if it can be avoided. Where emphysema is due to the external air being drawn in through a wound during respiration, the treatment will be to force out again as much air as possible, and to close the wound. Where it is due to penetrating wounds of the lung, is the external wound to be closed or left open? Both plans are liable to objection; thus, if the wound be closed, there is no direct vent for the air to escape, and the effusion continues to extend more rapidly; and, on the other hand, if the wound be left open, the external air may be drawn in and increase the mischief.

Larrey[*] gives an excellent case in point: 'The emphysema arose from a wound of the lung by a lance. The whole body was prodigiously swelled; the integuments so distended that the limbs were inflexible, the eyes buried, and the lips so enlarged that nothing could be introduced into the mouth. The pulse and respiration were scarcely perceptible, and the voice feeble and interrupted. The lance had entered obliquely, under the lower angle of the scapula, and although the external and internal orifices of the wound were not parallel, the surgeon had applied adhesive straps, and closed the external one. Hence the air, as it escaped from the lungs, distended the cellular tissue.' Larrey immediately removed the dressings; and with a bistoury made the opening in the pleura and skin parallel. Cupping-glasses were then applied over the wound, and quickly filled with air and blood. The lips of the wound were now brought together, and kept so with a suitable bandage. Cupping-glasses and scarificators were applied to various parts of the body; and in others incisions were made with a scalpel. The patient recovered.

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[*] *Mém. de Chir. militaire*, t. iv.

The constitutional measures will be, to relieve any urgent dyspnœa, to diminish the violence of the respiratory efforts, and to lessen the heart's action, taking care not to depress the patient too much. Antimony and ipecacuanha are the most essential remedies, given in full and repeated doses. Venesection must be employed where there is much pulmonary congestion and oppression of the circulation.

b. Pneumo-thorax is when the air is confined to the cavity of the pleura, and is generally concomitant with emphysema, so that the two might be treated of together; however, to render the subject less complicated, they are described separately. The causes of this accident are the same as those of emphysema, and the same remarks apply to it. When it occurs in a moderate degree and in conjunction with emphysema, it does not attract the surgeon's notice; but his attention is at once arrested when it begins to interfere with the lungs, and compresses them towards the spine and centre of the thorax. Pneumo-thorax may also arise from disease of the lung, especially in phthisis; hence its study is more appropriately referred to in works on medicine. In this place, reference will be made only to its symptoms and treatment in connection with injuries and wounds of the chest. The symptoms are, urgent and distressing dyspnœa, tympanitic resonance of the chest on percussion, amphoric respiration, and a kind of metallic tinkling or a ringing metallic resonance on auscultation, if the lung is not too much compressed.

The treatment will consist, when the symptoms are urgent and threatening, in allowing the air to escape externally, either by enlarging the wound, or, if there be no wound, by introducing a trocar and canula, as in paracentesis thoracis, described a few pages further on.

c. Hæmo-thorax is hæmorrhage into the cavity of the pleura.

This is so remarkably well described by John Hunter,* in his treatise on 'Gun-shot Wounds,' that we cannot refrain from quoting the following remarks. 'In the cases of stabs, especially if with a sharp instrument, the vessels will bleed freely, but the external wound will collapse and cut off all external communication. If the lungs are wounded in the same manner, we must expect considerable bleeding from them, and this bleeding will be into the general cavity of the thorax (if the lungs at this part have not previously adhered there), and likewise into the cells of the lungs or bronchiæ, which will be known by producing a cough, and, in consequence of it, a bleeding at the mouth; for the blood that is extravasated into the air-cells of the lungs will be coughed up by the trachea, and by that means will become a certain symptom of the lungs being wounded; but that which gets into the cavity of the thorax cannot escape, and therefore must remain till the absorbents take it up, which they will do, if it is only in small quantity; but if in large quantity, this extravasated blood will produce symptoms of another kind.'

The symptoms will depend, in a great measure, on the quantity of blood poured out within a definite period. Where the blood is effused immediately and in large quantities, there will be all the signs of internal hæmorrhage, and death speedily ensues, owing to the immense loss of blood, and suffocation from pressure on the lungs. This generally takes place in extensive wounds of the lung, but may also occur from wound of the large vessels in the chest, or even from wound of the intercostal vessels. The signs are, great oppression and uneasiness, restlessness, and sitting up in bed, with the body bent forwards; the countenance and surface become deadly pale and cold, and this is followed soon by syncope and utter prostration, the patient lying almost motionless in bed, with the legs drawn up, and an occasional heaving of the chest; with dilated pupils and glassy eye, clammy perspiration and weak fluttering pulse.

Where the effusion of blood takes place slowly, recovery may be anticipated, and the symptoms of such effusion may be well illustrated from Hunter's work: he says: 'The symptoms of these accidents are, first, a great lowness, which proceeds from the nature of the parts wounded, and perhaps a fainting from the quantity of blood lost to the circulation; but this will be in proportion to the quantity and quickness with which it was lost. A load in the breast will be felt, but more from a sensation of this kind than from any real weight, and a considerable difficulty in breathing. This difficulty in breathing will arise from the pain the patient will have in expanding the lungs in inspiration, and will also proceed from the muscles of respiration of that side being wounded; and this will continue for some time, from the succeeding inflammation: it will hinder the expansion of the thorax on that side, and of course in some degree of the other side, as we have not the power of raising one side without raising the other; and if wounded by a cutting instrument, the lungs of that side, not being able to expand fully, by the cavity of the thorax being in part filled with blood, will also give the symptoms of difficulty of breathing. The patient will not be able to lie down, but must sit upright, that the position may allow of the descent of the diaphragm, to give room in the chest.'

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* *Hunter's Works*, by Palmer, vol. iii. pp. 567 et seq.

The diagnosis will depend on certain rational and physical signs: the rational are, firstly, the symptoms peculiar to all abundant hæmorrhages, such as syncope, vertigo, paleness, &c.; and, secondly, the functional disturbance of respiration, such as dyspnœa, short and hurried breathing, continual agitation and change of position. These symptoms are by no means conclusive, as they may be present without any effusion in the chest; and, on the other hand, patients may die of effusion of blood in the chest, without any serious impediment to the respiration. The physical signs are more to be depended upon: they are ascertained; 1st, by mensuration, which enables us to detect the enlargement of the chest on one side, the bulging of the intercostal spaces, and the diminished mobility of the ribs; 2nd, by percussion, which will indicate dulness, or even a complete absence of all resonance; 3rd, by auscultation, which will detect an absence of respiratory murmur, and by careful watching may even enable one to trace the effusion as it increases upwards; 4th, by succussion, either felt by the patient or produced by the surgeon: where present, it is a good test, but it is often unattainable; 5th, by the appearance of ecchymosis in the lumbar region at the base of the chest, according to Valentin and other surgeons, who describe it as taking place several days after the injury, and as extending from the angle of the false ribs towards the quadratus lumborum muscle, and as being of a deep violet colour, in consequence of a transudation of the blood from the chest: however, this sign is not always present, and its absence may deceive the surgeon, as happened to Sancerole, who declined to perform paracentesis because there was no ecchymosis, and yet, on examination after death, a pint of blood was found in the chest.

The treatment considered to be most judicious, is to close the external wound, and to allow the effused blood to coagulate if possible, and thus form a plug against further hæmorrhage; the effusion may prove to be inconsiderable, and provided no air has decomposed the blood, and there be only slight subsequent inflammation, the whole may become absorbed. Should, however, the effusion increase, and cause the above-named symptoms, paracentesis must be performed. Some recommend that the external wound should be kept open, and the patient placed in such a position as to enable the fluid blood to flow out, and to persevere in this measure; Ambrose Paré mentions several such cases as being successful. Others, again, prefer enlarging the external wound, so as to allow a more speedy escape for the effused blood; and this also has been attended with success in several instances. With regard to the attempts at the removal of the blood by means of a tube and pump, this method is attended with too great a risk, as the pleura and lung may be injured; and in respect to the injection of fluids into the chest to soften down and break up the clots, as has been actually proposed, this would be only substituting one effusion for another.

d. Penetrating wounds of the chest, complicated with the presence of *foreign bodies*, are always to be considered dangerous, inasmuch as they may set up inflammation and its consequences. The foreign body may be lodged in the parietes, or it may enter the pleural cavity and fall upon the diaphragm; or, again, it may pass into the pericardium; generally, however, foreign bodies enter the lungs or heart: in rare instances, especially if the substance be small, such as a bullet, it may become encysted, and remain quiescent for years.

When the foreign body is lodged in the parietes, it must be extracted forthwith; but some difficulty may be experienced, as is recorded by Sabatier,[*] in the case of a man aged twenty-seven, who was struck very violently with a knife on the outer part of the fourth true rib; considerable coughing and spitting of blood ensued, and the symptoms were found to depend on the presence of a piece of the knife, which had pierced the rib, and was projecting some way into the thorax. So little of the foreign body was on the outside of the rib, and it was so fixed in the bone, that it could neither be extracted with any kind of forceps, nor even moved in the least with a leaden mallet, &c. M. Gerard conceived that an attempt might be made to extract the foreign body by pushing it from within outwards. For this purpose, having put a steel thimble on his index finger, he introduced it into the cavity of the thorax, and thus succeeded in pushing out the piece of the knife. The patient recovered.[†]

Malle, in 1843, trepanned the fifth rib, in which the blade of a knife was impacted (which could not be seized with forceps). Recovery ensued: but this is a dangerous proceeding, on account of the neighbourhood of the pleura.

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[*] *Méd. opératoire*, tom. ii.

[†] M. Vidal throws some doubt upon the propriety of this proceeding: he says, 'It is not easy to introduce the finger armed with a thimble through an intercostal space; and even should it be practicable, great risk is run of the thimble coming off and falling into the chest on withdrawal of the finger.'

When the foreign body has entered the pleural cavity, its presence is rendered very obscure in consequence of the speedy inflammation, and the almost necessarily ensuing empyema. Its diagnosis must be based upon, 1st, the penetration of a body, or ball, which has not passed out, and which is followed by thoracic symptoms; 2nd, the absence of all signs of wound of the lung; 3rd, irritation and inflammation of the diaphragm, from the ball or foreign substance gravitating to the bottom of the chest.

In the case of policeman Thain, who was shot whilst bringing a prisoner from Hamburg, the symptoms were at first so slight that the wounds were regarded as being superficial; but after several days, sudden symptoms of empyema set in, together with great diaphragmatic pains and dyspnœa, and speedy death. On examination, one ball was found lodged in the intercostal space, another in the diaphragm, and a third was rolling about loose in the chest; but the lung was uninjured.

Larrey was more successful, for in one of his cases he made an incision into the chest, and, after evacuating about twelve ounces of pus, he succeeded in removing the ball by means of a polypus forceps, having previously ascertained its presence by the introduction of a sound. The general effects of such injuries are pleurisy, empyema, hectic fever, and death.

When the foreign body has entered the lung, an unfavourable prognosis must be given; but some remarkable instances of recovery are on record.

Mr. South* mentions the case of a sailor, aged nineteen, whose chest was transfixed by the bolt of the trysail-mast (five inches and a half long, and two inches and a half wide). It entered between the fourth and fifth left ribs, fracturing the fourth about one inch and a half from the sternum, and made its exit between the eleventh and twelfth ribs, four inches to the left of the spine. There was difficult breathing, hæmoptysis, and threatening suffocation. The wound was closed by lint and strapping; he was freely bled, both locally and generally, and put under the influence of mercury. He recovered and went to sea, was shipwrecked twice, and saved his life by swimming a considerable distance. He was seen ten years afterwards, and was then quite well. Velpeau † cites the case mentioned by Guillon, that of a convict who died at Rochefort, and in whose chest was found a part of a fencing foil; this had traversed the chest from one part to the other, and one of the extremities was implanted in the rib, while the other end was fixed in the spine; the middle part was in the centre of the lung, surrounded by calcareous deposit. It was ascertained that the wound took place fifteen years before, and there was no suspicion of the presence of a foreign body. In the Museum of the Royal College of Surgeons of England is recorded the case of T. T., aged thirty-five:—the shaft of a chaise was forced between the ribs on the left side, through the cavity of the thorax behind the sternum, and made its exit between the ribs on the right side, without injury to the large vessels, lungs, &c. It was withdrawn, and he walked up two flights of stairs to bed; he had difficulty of breathing, pain and weight in the chest, vomiting and hiccough. He was bled very largely and blistered. He recovered, and lived for five years without inconvenience, when he began to suffer from difficulty of breathing and irregular action of the heart. He died ten years after the accident. The lungs were adherent to the parietes, and the pericardium entirely adherent to the heart, which latter was larger than usual.

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* South's *Chelius*, vol. i. p. 441.

† *Presse médicale*, tom. i. p. 151.

The secondary complications or the consecutive effects of penetrating wounds of the chest have already been cursorily alluded to, viz. pleurisy, pneumonia, and empyema. The symptoms, diagnosis, prognosis, and treatment of these diseases hardly come under consideration in this place, and the reader must therefore be referred on these points to the standard works on medicine; but, at the same time, the surgeon must bear in mind that he is bound to possess an accurate knowledge of all these complications, so that he may be enabled to anticipate and detect the coming mischief, and thus check and repel it by suitable treatment.

However, it has been deemed advisable to enter into some further particulars respecting the operation for the relief of empyema and other effusions in the chest. This operation the surgeon is sometimes called upon to perform, and it behoves him well to consider the general symptoms necessitating its performance, and the local manifestations which guarantee its probable success.

The operation is termed paracentesis thoracis, or thoracentesis. Before operating, it is essentially requisite to make an accurate examination of the chest by means of auscultation and percussion, so as to determine the existence as well as the locality of the fluid or air in the chest; and then to select a proper situation for its evacuation, making use of appropriate instruments; as well as to guard against all difficulties which may occur during the operation.

There are many objections raised against the operation, but these, when carefully considered, do not in any way militate against its performance; the following are the chief circumstances urged against it: 1st, the necessary introduction of air into the cavity of the chest; 2nd, the impossibility of entirely emptying the chest; 3rd, the danger of taking away too great a quantity of fluid; 4th, the impossibility of breaking down old adhesions; 5th, the probable rupture of the air-cells and vesicles; 6th, the production of pleurisy and pneumonia; 7th, the more rapid reproduction of the fluid, after the operation; 8th, the possibility of the persistence of thoracic fistula.

These objections do not require to be entered into seriatim in the present essay; we shall therefore merely give the result of twenty-five cases, taken indiscriminately, in which it was performed at Guy's Hospital during a given period. Dr. Hughes, in his summary, remarks that 'the operation was performed in twenty-five cases, in some once, and in others several times. Of these cases, thirteen may be fairly stated to have recovered, so far as regards the effusion into the pleural cavity: two may be justly mentioned as having at least partially recovered; one of these has, after seven years, a fistulous opening into the pleura, and the other has still some, though comparatively a very small quantity of fluid in the right pleura, but feels so much better as to be actually in search of employment in his profession. Ten have ultimately died of other diseases, generally connected with that for which the operation was performed, but entirely independent of its performance. Of these ten cases ultimately fatal, six have died of phthisis; one of gangrenous pulmonary abscess of the opposite side; one after three months of chronic pneumonia; one rather suddenly, with hydro-thorax in the other pleura; and one, a case of pneumothorax with effusion, of pneumonia and pericarditis.'*

With regard to the situation in which the operation should be performed, the place of election, as it is called, three indications have to be borne in mind, viz. to procure a sufficiently depending opening, to avoid wounding the diaphragm, and the intercostal vessels.

Mr. Cock, in his remarks appended to Dr. Hughes's paper in the *Guy's Hospital Reports*, observes, 'In the great majority of instances the existence of the fluid would be most clearly indicated at the lateral and posterior part of the chest, in a position somewhat central between the upper and lower boundaries; and in every case which has come under my own hands I have had occasion to tap below the angle of the scapula, between the seventh and eighth ribs, or the eighth and ninth ribs, and at a point distant from one to three inches from the angles of the bones. Our incapability of judging of the exact position of the diaphragm, and the alterations which are liable to occur about the floor of the chest from recent or old adhesions between the muscle and the base of the lungs, would lead me to deprecate the practice of making a low puncture. When we have the choice of two or three intercostal spaces, I would select the upper or, at any rate, the middle one, as the safest, and least obnoxious to those casualties which may induce a failure in our object: any advantage supposed to result from a depending opening can readily be obtained by adapting the position of the patient to our purpose.'

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* *Guy's Hospital Reports*, 2nd Series, vol. ii. p. 366.

M. Malgaigne's* instructions are, that, 'to avoid the arteries, the middle third of the contour of the chest, midway between two ribs, is to be selected, and, in order to avoid the diaphragm, the third or fourth intercostal space, counting from below upwards, should be preferred; in France it is usual to select the third space on the left side, and the fourth one on the right, in consequence of the liver.' He also states, that the required intercostal space can always be found, in thin subjects, by counting upwards from the twelfth rib; but in fat and well-developed persons there is much difficulty in recognising it; as a proximate guide it will be about six fingers' breadth below the inferior angle of the scapula; the best method is to take as a starting point the last rib attached to the sternum, which is the seventh, and, on tracing it round the chest, it will give the sixth intercostal space above it, and the seventh below it.

The various modes of opening the chest are, 1st, by cauterisation; 2nd, by incision; and 3rd, by a trocar and canula, which is termed tapping, or paracentesis.

The proceeding by cauterisation is obsolete; the pain and great length of time necessary for effecting its purpose have rendered it quite inadmissible.

The operation of making an incision into the chest has been confined to the extraction of foreign bodies; and in this country it is seldom had recourse to for evacuating fluids from the chest, although it is preferred by some of the Continental surgeons. It, however, sometimes leads to mischievous results as liable to allow free ingress of air into the cavity.†

The operation by means of the trocar and canula is the one usually recommended and adopted. By Mr. Edward Cock's permission we are enabled to make use of the following extracts from his excellent paper in the *Guy's Hospital Reports*, where the whole subject is fully discussed.

And, firstly, with respect to exploration previous to performing paracentesis. 'Notwithstanding the perfection to which auscultatory diagnosis has been brought, and the exactness with which a practised ear is enabled to appreciate the deviations from natural structure and function within the thoracic cavity, the most experienced practitioner will sometimes be mistaken in his opinion, or, at any rate, puzzled by modifications of disease and conflicting evidence, which tend to obscure the clear signs of the presence of fluid. Under such circumstances it is always advisable, previously to tapping the chest, to explore the part in such a manner as shall, at any rate, inflict no injury on the patient, although its result may convince us of the inutility of a further operation. For this purpose, the grooved needle was invented and used; but, although applicable to many other purposes, it is at best a clumsy and inefficient instrument for exploring the chest, and frequently has left us as much in doubt after its withdrawal as previous to its introduction. The groove is so easily obstructed by the tissues through which the instrument passes, or by small particles of lymph, as to render the escape of fluid, which may really exist, a matter of great uncertainty. An instrument admirably adapted for exploration has been contrived by Dr. Babington. It consists of a needle contained in the smallest-sized canula; this is passed between the ribs into the suspected spot; the needle is withdrawn, and the escape of fluid from the tube at once indicates the existence and nature of the abnormal secretion. A further investigation, as to the size and direction of the cavity, may also be obtained by introducing a fine silver probe through the canula.'

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* *Méd. opératoire*, p. 532, 3^{me} édit.

† M. Vidal (*Traité de Path. ext.* 1861, tom. iv.) proposes a double operation: in the first instance, he makes an incision through the parietes to the pleura and then allows the wound to be kept open until suppuration sets in, when he inserts a small fragment of caustic potash, so as to cause a slough, and thus evacuate the contents: this secondary operation may be performed by a bistoury or trocar instead of the caustic. He denominates it the operation '*en deux temps.*'

Secondly, with respect to the operation itself, Mr. Cock observes: 'The trocar and canula which I have found best adapted for general use is about one-twelfth of an inch in diameter, and about two inches in length, exclusive of the handle. I prefer a circular to an oval instrument, as the former is more easily introduced and does less injury to the intercostal muscles, whose fibres are perpendicular to the long diameter of the oval canula. The small canula has many advantages; its introduction is easy, and attended with little friction; it gives but very slight pain, and it is calculated to elude the nerves and vessels; on its withdrawal, the opening which it has made becomes immediately and permanently closed, thus at once restoring the integrity of the cavity which has been entered; it is adapted to all ages, from the infant to the adult, and can hardly fail to find its way between the ribs, however narrow the intercostal space may be: again, it insures a slow and gradual evacuation of the fluid, and enables us to avoid the admission of air; at the same time allowing a better opportunity for the lungs to expand, and enable us more effectually to empty the cavity.' Mr. Cock thus concludes: 'It now only remains for me to describe the operation itself, which, as regards the pain it inflicts, is so trifling, that, by avoiding all unnecessary display and preparation, the patient may be led to consider it as little more than the sequel of the discipline to which he is occasionally subjected when it is considered essential to make a thorough examination of his chest; the same position of the body being alike adapted for the one process as for the other. It will be found most convenient to let the patient sit *across* the bed, so as to admit of his body being readily lowered and supported over its edge. The spot having been determined upon, it is advisable to make a small puncture in the skin, just at the upper edge of the rib, with a narrow-bladed lancet; through which opening the exploring needle and subsequently the trocar may be inserted. This preliminary step is not absolutely necessary; but as the skin is by far the most impenetrable and resisting of the tissues to be traversed, its previous division will render the introduction and withdrawal of the canula more easy, less forcible, and attended with a minor degree of pain and alarm to the patient. The exploring needle having been first introduced and the presence of fluid ascertained, the trocar and canula may then be carried into the chest through the same track, giving the instrument a slight obliquity upwards, which will enable it to clear the edge of the rib. The depth to which the trocar must be passed will of course depend much on the thickness of the parietes, the presence of fat, muscle, or œdema, for which due allowance should be made; and, in most instances, the penetration of the pleura will be appreciated by the sensation conveyed to the fingers of the operator, especially if the integument has been previously incised so as to diminish materially the friction.

'The remainder of the operation consists in getting rid of as much fluid as the strength and condition of the patient will bear, and carefully avoiding the admission of air into the cavity. On withdrawing the trocar, the fluid will at first be found to flow in a steady and equable stream, slightly augmented in force at each expiration. After the lapse of a shorter or longer period, the flow will become checked at each inspiration, and then the body of the patient should be gently lowered into a horizontal posture, and turned slightly on to the affected side, so as to bring the cavity directly over the opening; and in this position he should be duly supported by assistants. The fluid will now recommence flowing in an uninterrupted stream; and when it again begins to flag, a still further quantity may be obtained, if the state of the patient permit it, by directing an assistant to make steady and continuous pressure on the lower part of the chest, by grasping it on either side with the hand. This may be kept up for a period varying from a few seconds to a minute, until a continuous stream can no longer be obtained, when the canula should be immediately withdrawn. The greatest care should be taken to remove the tube, and thus close the opening, while the chest of the patient is yet in the grasp of the assistant; for, if he relax the pressure while the communication with the pleural cavity be still open, air will infallibly rush in.

'During the whole process of evacuation the unremitted attention of the operator should be directed to the stream of fluid, which he should never allow to become completely interrupted during the effort of inspiration. The admission of the slightest quantity of air is immediately indicated by a peculiar sucking noise, which cannot be mistaken, and which should be the signal for the prompt withdrawal of the canula. The wound requires nothing but the application of a small dossil of lint and a strip of plaster; and the patient may then be laid down in bed.'

Of late years M. Chassaignac has introduced a plan of treatment for the healing of sinuses, and cure of deep-seated abscesses and extensive collections of matter, by what he terms 'drainage-tubes.' His plan consists in procuring an india-rubber tube, having a diameter of about one-sixth of an inch, and perforated at frequent intervals by notching it with scissors; and then introducing this into the abscess or sinus, so as to allow the matter continuously and uninterruptedly to exude through the perforations.

This method has more recently been employed in the treatment of empyema; thus, after the ordinary operation of paracentesis, a firm, long iron probe, somewhat bent, and having a strong piece of silk passed through its eye, is introduced into the opening and directed towards the lower and back part of the cavity; the end of the probe is then made to press against the sides of the thoracic walls, so that it may be felt externally between the intercostal spaces, when an incision is to be made upon it, and the probe brought through the opening thus made. Having secured the drainage-tube to one end of the silk, it is to be drawn through and brought out externally, and the two ends of the tube tied together outside.

The plan has been tried in this country on several occasions,* but has not found many advocates; the usual method as above given being generally preferred.

Fistulous openings may become permanently established, and the surgeon's attention is sometimes directed towards effecting a cure.†

2. *Wounds of the mediastina, pericardium, and heart.*—Wounds of the mediastina generally compromise the parts contained therein, such as the large vessels, nerves, œsophagus, &c.; they are, therefore, attended with serious results, and take on the characters of the major lesion. But now and then no important structure is implicated, the weapon or instrument merely entering the loose cellular tissue of which the space is composed: a circumstance already alluded to when treating of foreign bodies in the chest, where a case was related of the anterior mediastinum being traversed from side to side behind the sternum, without any important structure being involved. This class of accidents is rare, and when they occur they are liable to be followed by inflammation of a diffused character, which is exceedingly prone to run on to suppuration, or may by contiguity set up pleurisy and pericarditis. In any case, a guarded prognosis must be given. The symptoms are exceedingly obscure, and are of a negative character only, viz. the absence of signs of pleurisy and pericarditis, and yet the presence of inflammatory symptoms. When suppuration takes place, it will often induce pyæmia and death, without giving any external evidence of its existence. Some surgeons have recommended the trephining of the sternum in cases where deep-seated suppuration is anticipated; but this measure can seldom be had recourse to, inasmuch as there is so much obscurity that no accurate diag-

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* See *Med.-Chir. Trans.* vol. xlii. p. 231.

† On the treatment of fistula after empyema, see *Archiv. der Heilkunde*, p. 84, 1864. Boinet advocates the injection of iodine into an empyemic cavity.

nosis can be made. Where wounds of the mediastina are complicated with fractured sternum, fractured ribs, wounds of the lungs, heart, &c., the conditions are rendered much more serious.

Wounds of the pericardium seldom occur alone, being most frequently associated with other severe lesions. They are generally complicated with wounds of the heart, internal mammary artery, diaphragm, œsophagus, &c., to which individual lesions reference must be made. But when the pericardium is alone involved, the wound will give rise to pericarditis; the symptoms, diagnosis, prognosis, and treatment of which must be learned from the standard medical works. Death need not be the immediate result of a wound of the pericardium, as proved by the case quoted by Sir A. Cooper; viz. that of a man who was wounded by a reaping-hook deeply through the cartilages of the ribs. The wound was small; the man had the appearance of one having sustained a dangerous injury, and in two or three days he complained of much pain in the region of the heart, and a quick, small pulse; he shortly began to swell, and could not lie down in bed: he lived for two or three weeks, and after death an effusion of bloody pus was found in the pericardium. Hennen relates a case, where there was a bayonet-wound of the pericardium and diaphragm, and where the patient recovered from its immediate effects, but succumbed to pneumonia three months after. The heart, in this case, was found adherent by long fibrinous bands to the pericardium.

For further references to wounds of the pericardium, see the annexed table from Fischer.

Wounds of the heart are for the most part met with in gunshot wounds, but they may be seen in the other forms, namely, in the incised, punctured or lacerated varieties.

Some authors have divided them into penetrating and non-penetrating wounds, according as they involve the cavities or parietes of the heart: this subdivision is of little practical importance, for both are attended with equally fatal results; death taking place either immediately from hæmorrhage or consecutively from acute pericarditis.

The following statistical tables of 452 cases of wounds of the heart and pericardium are taken from Dr. Fischer's work,* which contains a very exhaustive article on the subject, comprising a short abstract and analysis of all the recorded cases.

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* Dr. G. Fischer, *Ueber die Wunden des Herzens und des Herzbeutels. Archiv. f. klin. Clin. von Langenbeck,* 1868. Band ix. p. 571.

Situation of Lesion.	Punctured Wounds.				Incised Wounds.				Gun-shot Wounds.				Lacerated and Ruptured Wounds.				Time of Death uncertain.				Total.	
	Death.		Recovery.		Death.		Recovery.		Death.		Recovery.		Death.		Recovery.							
	Immediate.	Not immediate.	Proved by Inspection.	Conjectured by Symptoms.	Immediate.	Not immediate.	Proved by Inspection.	Conjectured by Symptoms.	Immediate.	Not immediate.	Proved by Inspection.	Conjectured by Symptoms.	Immediate.	Not immediate.	Proved by Inspection.	Conjectured by Symptoms.	Punctured Wound.	Incised Wound.	Gun-shot Wound.	Lacerated and Ruptured.		
Right Ventricle	2	6	2	—	19	54	5	4	4	10	5	—	2	1	—	—	—	3	3	3	123	Right Ventricle.
Left Ventricle	—	10	4	—	17	36	1	1	3	9	—	—	5	5	—	—	1	3	4	2	101	Left Ventricle.
Both Ventricles	—	4	—	—	7	5	2	—	1	1	—	—	1	1	—	—	—	2	2	—	26	Both Ventricles.
Right Auricle	1	1	—	—	—	10	—	—	1	—	—	—	5	3	—	—	1	1	1		28	Right Auricle.
Left Auricle .	—	—	—	—	1	4	—	—	1	—	—	—	3	2	—	—	—	—	—	2	13	Left Auricle.
Septum Ventr.	—	—	1	—	—	2	—	—	—	1	—	—	—	2	—	—	—	—	—	1	7	Septum Ventr.
Apex . .	—	—	—	—	—	7	3	1	—	2	—	—	—	2	—	—	—	1	—	1	17	Apex.
Base . .	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	2	Base.
Whole Heart .	—	—	—	—	—	2	—	—	2	—	—	—	8	—	—	1	—	—	3	—	16	Whole Heart.
Right Heart .	—	—	—	—	3	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	4	Right Heart.
Left Heart .	—	—	—	—	—	1	—	—	3	—	—	—	—	—	—	—	—	—	1	—	5	Left Heart.
Coronary Art.	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	2	Coronary Art.
Uncertain .	1	1	1	2	6	13	6	5	4	2	—	1	3	1	1	1	1	1	—	7	57	Uncertain.
Pericardium .	—	3	—	—	—	15	2	11	—	1	1	4	1	1	—	4	—	4	1	3	51	Pericardium.
104 Immediate Death .	4	—	—	—	53	—	—	—	19	—	—	—	28	—	—	—						
219 Not Immediate Death	—	26	—	—	—	149	—	—	—	26	—	—	—	18	—	—						
72 Recovery .	—	—	8	2	—	—	21	22	—	—	6	6	—	—	1	6						
57 Uncertain	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	15	15	23	452	
452																						
	40 + 4 uncertain.				245 + 15 uncertain.				57 + 15 uncertain.				53 + 23 uncertain.				Total uncertain 57.					

FOREIGN BODIES IN HEART AND PERICARDIUM.

No.	Foreign Body.	External entrance.	Duration of Life.	Situation in Heart.	Size and Shape of Foreign Body.	Remarks.
1	Needle.	?	18 days.	Entirely in the wall of right ventricle.	3 inches long.	Hypertrophied heart—pericard.
2	do.	Sternum.	6 years.	ditto.	— —	Covered with lymph.
3	Ball.	Thorax.	20 years.	ditto.	— —	Hypertrophied cicatrix.
4	Needle.	?	1 year.	Entirely in the wall of left ventricle.	2 inches long, broken and oxidised.	Encapsuled.
5	Paper wadding.	Thorax.	7 hours.	ditto.	— —	Filled half the ventricular wall.
6	Ball.	Thorax.	12 days.	Entirely in the wall of septum ventr.	1 inch long.	Encapsuled—pericarditis.
7	Toothpick, ivory.	?	10 to 12 hours.	In the wall and cavity of right ventricle.	$1\frac{1}{2}$ inches.	— —
8	File.	Thorax.	21 days.	In the wall and cavity of left ventricle.	Broken off.	— —
9	Splinter of wood.	—	47 days.	ditto.	— —	— —
10	Needle.	Thorax.	9 months.	In the wall and cavity of both ventricles.	— —	Head in right and point $\frac{1}{4}$-inch in left ventricle.
11	Iron stilet.	Thorax.	20 days.	ditto.	4 inches long, 2 lines thick.	Firm in heart, point in right ventricle.
12	Needle.	Œsophag. ?	Long time.	In the wall and cavity of right appendix.	1 inch long.	Firm in heart—aneurism of descending aorta.
13	Needle.	?	?	In the wall and cavity of left ventr.	Rather more than 1 in. long.	Surrounded by fibrine.
14	Ball.	Thorax.	Some years.	In the cavity of right ventricle.	Flattened.	Cicatrix in heart.
15	Ball.	Thorax.	—	ditto.	do.	Fell out of art. pulm.
16	Ball.	Thorax.	6 years.	ditto.	— —	Encapsuled — cicatrix in heart.
17	Shot.	Thorax.	67 days.	ditto.	— —	Free — hypertrophied cicatrix.
18	Wooden peg.	Thorax.	5 weeks.	ditto.	3 inches long.	Shot through lung, vena cava, &c.
19	Hair wadding.	Thorax.	26 days.	ditto.	— —	—

20	Thorn.	Œsoph.	$1\frac{1}{2}$ years.	In the cavity of right ventricle.	4 lines long.	Free, covered with fibrine, cicatrix in heart.
21	Bone.	Œsoph.?	8 days.	ditto.	$1\frac{1}{2}$ inches long.	Heart stuck in several places.
22	Needle.	Œsophagus.	—	In the cavity of left ventricle.	Long.	Death from gangrene of lung.
23	Needle.	Œsophagus?	—	ditto.	Long.	No external wound.
24	Ball.	Thorax.	10 weeks.	ditto.	— —	Through vena pulm.
25	Pieces of a gun.	Thorax.	7 weeks.	ditto.	— —	— —
26	End of dagger.	Thorax.	22 hours.	In the cavity of right appendix.	5 inches long.	Passed into lung.
27	Razor.	Thorax.	4 days.	Heart quite transfixed.	— —	— —
28	do.	Thorax.	6 days.	ditto.	— —	— —
29	Fish bone.	Œsophagus.	—	Uncertain—in heart.	$1\frac{3}{4}$ inches long.	Wound of stomach, and diaphragm.
30	Needle.	Thorax.	3 weeks.	ditto.	— —	Hypertrophy and adhesion of heart.
31	Needle.	Œsophagus.	Some days.	Pericardial bag.	$1\frac{1}{2}$ inches long.	Loose—rent in right ventricle, through the coronary vessels.
32	Ball.	Thorax.	24 hours.	ditto.	— —	Superf. erosion of rt. vent.
33	Ball.	Thorax.	14 days.	ditto.	— —	Free; injury of right vent.
34	Ball.	Thorax.	44 hours.	ditto.	— —	ditto.
35	Ball.	Thorax.	52 years.	ditto.	— —	Encapsuled—adhesions.
36	Gold tooth-plate.	Œsophagus.	5 days.	ditto.	2 inches long, 1 inch broad.	Teeth in the œsophagus, pericarditis.
37	Ball.	Thorax.	3 hours.	External to the pericardium.	Small.	Pericardium uninjured; lesion of right ventricle.
38	Needle.	Thorax.	6 to 7 weeks.	In the walls of the thorax—in cartilage of rib.	— —	Injury of pericardium and surface of heart.
39	Needle.	Thorax.	Momentary?	In the walls of the thorax—between ribs.	1 inch long.	Injury of pericardium and right ventricle, not penetr.
40	Needle.	Thorax.	—	ditto.	About an inch long.	Extracted—healed.
41	Needle.	Thorax.	10 to 12 hours.	In the walls of the thorax, between ribs and sternum.	1 inch long.	Lesion of right ventricle—not penetrating.
42	Needle.	Thorax.	1 hour.	ditto.	$1\frac{7}{8}$ inches long.	Lesion of aorta and pericardium.
43	Iron pin.	Thorax.	12 years.	In the walls of the thorax in sternum.	1 inch long.	Lesion of base of heart.
44	Needle.	Thorax.	$9\frac{1}{2}$ months?	In the walls of thorax under the skin.	$1\frac{1}{2}$ inch long.	Extracted—healed.
45	Needles.	Thorax.	21 days.	In the lungs.	Two needles.	Pericarditis—carditis.
46	Needle.	?	2 days?	Pericardial bag.	— —	3 wounds in the aorta.
47	Ball.	—	15 days.	In the wall of left ventricle.	— —	— —

The symptoms are exceedingly uncertain, but the most important one is the presence of a *lesion* in the neighbourhood of the heart, with *external bleeding*, followed by all the signs of sudden *internal hæmorrhage*; this latter, however, is by no means so frequent or so considerable as is generally imagined, for the blood poured out into the pericardium soon coagulates, and thus prevents further effusion: again, the blood may make its way into the mediastina or pleuræ, and complicate matters. *Dyspnœa* is by no means a constant accompaniment, for it may be absent, or come on gradually, or become immediately intense. Dupuytren* observed a peculiar tremor about the heart, with weakening of the arterial pulsation, attended with an undulous crepitation or peculiar bruit. The *pulse* is often unequal, small, and intermitting. The acute *pain* in the sternal region, remarked by some, is neither constant nor certain. The *position* also of the patient is by no means characteristic, for some lie on the left side, others on the back, without inconvenience, whilst some cannot lie down at all. *Auscultation* is of but little assistance.†

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* *Leçons orales de Clin. chir.* 2^{me} éd. 1839, tom. iii. pp. 201 et seq.

† Fischer gives the following analysis of the situation of the wound:—

258 cases in front of the thorax, of which 165 were on the left side and 38 on the right side, 30 over the sternum and region of the heart, and 25 uncertain. There were also 5 cases on the lateral region of the chest, 26 cases from wounds of the abdomen and 11 cases from behind.

He observed that syncope or collapse was the first and most important symptom, and might occur even at the moment of receipt of the injury, or not take place until some time after, and hence he classifies the cases into three categories, according to the rapidity of the development of this symptom.

Thus in 87 cases where it was recorded the following results were noticed.

The first set, where the collapse occurred at the time of the accident, comprised 30 cases, of which 20 were punctured and incised, 6 gun-shot and 4 lacerated and ruptured wounds. The symptoms lasted from 2 minutes to 4 hours; and death generally followed from a few minutes to 2 months, most frequently from the 6th to the 10th day.

The second set, where the collapse was not immediate, but came on some moments after, were 38; of these 33 were punctured and incised, 2 gun-shot and 3 ruptured wounds. In one of these, the wounded person could run 450 steps, another ascended several steps, a third walked 1½ mile.

The third set, where the collapse did not supervene for some time, but came on during the progress of the case, comprised 19 instances, 16 of which were incised and punctured and 3 gun-shot wounds.

In them the collapse was due probably to the giving way of the clot or plug in the heart, and secondary hæmorrhage. Such hæmorrhage may occur all at nce, or may be repeated at intervals; it is generally produced by incautious

These wounds are generally considered mortal, death taking place immediately, or in a few days. Immediate death is generally caused by the sudden arrest of the heart's action, induced by one of two causes—either by the accumulation of blood into the pericardium, pressing upon the heart and causing cessation of its action, or by a suddenly deranged cardiac innervation depriving the heart of its contractile powers, as seen in those cases of sudden death where little or no blood is found in the pericardium. There are, however, some instances of recovery. Dupuytren, indeed, takes a rather favourable view of these cases, regarding them as not being always mortal, and he instances the fact of acupuncture of this organ, adopted for the

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moving. Some cases were going on well for 28 days, when sudden death took place.

Intense *anxiety and fear* seldom comes on at the moment of the accident, but some little time after, and is considered by Fischer to be due to compression of the heart and lungs from internal bleeding. It may not come on for some time after, as in the case where there was perforation of the aorta, where the patient walked to the hospital and it was difficult to persuade him to stay, when sudden and intense anxiety with fear came on, followed by death. Death-fear, death-pangs, the peculiar aspect of one having mortal wounds, are often present; then the patient on requesting not to be moved may assume a quiet calmness.

The *weakness* may be due not only to loss of blood but to the nervous and mental depression and shock, which latter appears to be by far the most important point in relation to these wounds.

The *pain* in these cases Fischer refers to the wound of the pericardium; he regards wounds of the heart itself as little or not at all painful; and agrees with Boyer that the absence of pain is of diagnostic value. He adduces Harvey, Ollenroth, and Bamberger as confirming the complete insensibility of the heart; but on the other hand he quotes cases from Lapeyronie and Reiche, which prove the contrary; in their cases, when the cardiac substance was touched, syncope immediately ensued, and in one case the patient was aroused from his state of insensibility and cried out from intense pain.

With regard to *Dyspnœa* and the state of the respiration: Fischer finds dyspnoea recorded in only 70 cases; in 7 respiration was normal; but in general the respiratory movements were difficult, and at variable times dyspnœa came on, endangering life. This dyspnœa appeared to be due to the compression of the heart by the effusion of blood into the pericardium and pleura.

Auscultation furnishes the most varied results; the heart-sounds are sometimes normal; often they are masked and distant, and in some cases altogether absent.

Ferrus and Jobert maintain that an undulatory thrill is a constant and pathognomonic sign; the bruit being analogous to that observed in arteriovenous aneurism.

Fischer observes that there does not exist any pathognomonic abnormal bruit in wounds of the heart, and that sometimes no alteration in the sounds has been observed.

cure of cholera at Warsaw, being attended with comparative impunity: he also urges the possibility of a cure, as evidenced by animals killed in the chase, in whose hearts balls and cicatrices of former wounds have been found. Considering the ambiguity and uncertainty of the signs of a wound of the heart, recovery from such supposed occurrence can only be confirmed by the subsequent opportunity of post-mortem examination, as in the case cited by Sanson,* that of a medical student who recovered completely in twenty-eight days; he was wounded on the left side of the chest immediately below the nipple, and from the attending symptoms it was conjectured that one of the cavities of the heart had been penetrated; at the autopsy, some lengthened period afterwards, a cicatrix in the heart was visible. The case cited by Velpeau† is still more explicit; it is that of a coalman, aged fifty, who died in the Hospital of the Faculty; he had, nine years previously received a wound in the left side of the chest from a table-knife: the pericardium was found largely opened and adherent to the parietal cicatrix; fibrous lines traversed the whole thickness of the right auricle at a point corresponding to the breach of surface in the pericardium.‡

The duration of life after such wounds is variable; and this variation is by some considered to be due to the part of the heart which is involved: thus, Ollivier d'Angers § gives the following summary of sixty-one collected cases:

In 29 cases the wound was in the right ventricle.
12 " " left "
9 " " both ventricles.
3 " " right auricle.
1 " " left "
7 " the wound involved either the base or apex simply.

Of these twenty-nine cases of wounds of the right ventricle, with the exception of two, all lived not less than two days viz. 4, 5, 8, 9, 13, 15, 20, 23, and even 24 days, respectively.

M. Jamain (*Thèse de Concours*, Paris, 1857) has extended this inquiry, and has endeavoured to determine the relative frequency of wounds of the different regions of the heart. In a collection of 121 cases there were—of wounds of the

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* See Nélaton, *Pathol. Chir.* tom. iii. p. 472.

† *Traité d'Anatomie chir.* tom. i. p. 604, 2^{me} édition.

‡ Mr. Gay has deposited in the Museum of the Great Northern Hospital a heart which had received a punctured wound. The patient lived 9 days; there was reason to believe that the wound did not extend quite through the walls of the left ventricle; but that subsequently the force of the blood caused the remaining portion to give way and thus cause sudden death. The opening is about the size of a No. 5 catheter.

§ *Dictionnaire de Méd.*, art. 'Cœur.'

Right ventricle	43	Interventricular septa	2
Left „	28	Both auricles	1
Apex and base of heart	7	Left auricle and ventricle	1
Both ventricles	9	The whole heart	1
Right auricle	8	Coronary artery	2
Left „	2	No precise indication	17

In the 121 cases, instant or very rapid death was observed in 21 cases, thus distributed:

Right ventricle	6	Left side of heart	1
Left „	6	Heart crushed	1
The two ventricles	4	Wound of heart not indicated	1
Non-penetrating wound	1	Coronary artery.	1

The following are the statistics by Dr. Fischer on the duration of life in 276 cases, where death was not immediate.

DEATHS NOT IMMEDIATE.

Cases. No.	Time.	Punctured wound.	Incised wound.	Gun-shot wound.	Ruptured.
37	1 hour	5	26	3	3
46	From 1 to 24 hours	5	25	8	8
74	1 day to 1 week	7	60	6	1
40	2nd week	2	31	2	5
8	3rd week	4	3	1	—
3	4th week	—	2	1	—
1	5th week	—	—	1	—
2	7th week	1	—	1	—
1	10th week	—	—	1	—
2	2 months	—	1	1	—
1	6 months	—	—	—	1
4	9 months	1	3	—	—
57	Uncertain	4	15	15	23

LONGEST DURATION OF LIFE.

	Punctured wound.	Incised wound.	Gun-shot wound.	Rupture.
Right ventricle	18 days	18 days	2 months 6 days	12 days
Left „	21 days	9 weeks	10 weeks	8 days
Both ventricles	8½ months	5 days	—	1¼ hours
Right auricle	Long time	15 days	—	14 hours
Left „	2 days	2½ hours	—	2 days
Septum ventriculorum	10 days	12 days	12 days	4 hours
Apex	1 day	20 days	7 days	9 hours
Base	—	—	7 days	—
Coronary art.	8 days	—	—	—
Pericardium	2 or 3 weeks	Several days	2 days	8 days

For reference to these cases see Fischer, op cit.

The duration of life does not bear any proportion to the extent of the wound; thus, in the well-known case quoted in most French works of the celebrated first grenadier of France, who received a lance wound between the sixth and seventh ribs, which implicated the anterior parietes of the left ventricle of the heart, it caused immediate death; and on examination half an hour afterwards, the pericardium presented a rent of four to five centimètres, and contained but little blood; the wound in the heart was very small and very superficial. Again, in the year 1728, one of the ladies of the Sardinian court ran a long gold needle into the chest of her husband, whilst asleep, and caused his sudden death: on examination, the right ventricle was found pierced through and through. The thinness of the parietes of the auricles is not the cause of a more rapid death; thus in the case of the Duc de Berri, whose right auricle was traversed by a saddler's awl, he lived eight hours; and in the case quoted by Blagny,* where the right auricle was wounded, the patient survived five days.

The direction in which the wound is made will materially affect the duration of life; thus, if made in the course of the muscular fibres, there may be little or no hæmorrhage; but if the heart is cut across, the edges will separate to a great extent, and sudden death occur from the immediate gush of blood.

The following recorded cases are instances of long survival after wounds of the heart. Breschet † quotes the case of a man who was thrust against a wall by the shaft of a cart, causing fracture of the sternum and the fourth, fifth and sixth ribs, and laceration of the pericardium, with superficial lesion of the left ventricle to the depth of one-third of its substance; he lived twelve days: on examination, there was no fluid in the pericardium, but a large quantity of blood in the left pleura. Ferrus relates the case of a man living twenty days with a skewer traversing the heart from side to side. David and Steward found a piece of wood, three inches long, in the right ventricle of a boy, who lived five weeks after the accident. Dupuytren, in his *Leçons orales,* records in full three cases of wound of the heart; one living nine days, the second three weeks, and the third three days: their perusal will well repay the attention of those interested in such matters. There is a remarkable case of survival for twenty-four hours, related by Dr. Babington: ‡ a marine fell upon his bayonet, which entered the abdomen, passed through the sigmoid flexure of the colon, through the stomach, the left lobe of the liver, the diaphragm and pericardium, and traversed the heart near the tricuspid valve; then penetrated the lung, and made its exit at the anterior part of the chest between the second and third ribs on the right side.

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* *Journal de Médecine,* an xl.

† Breschet, J., *Répertoire d'Anatomie et de Physiologie,* 1826, tom. ii.

‡ *Medical Records and Researches,* p. 59.

Much further detail and many curious cases may be found in works on Military Surgery. The popular notion of persons springing up in the air, when shot through the heart, is not verified by facts.

Recovery.—The general idea is, that wounds of the heart are mortal, and even now recovery is considered doubtful by many. But of 452 cases, there were 72 recoveries. In 36 cases, this was proved afterwards by inspection; but in the other 36, the wound was only conjectured from the symptoms present.

Punctured wounds	10 cases	8 proved by inspection	2 from symptoms.
Incised wounds	43 „	21 „	22 „
Gun-shot wounds	12 „	6 „	6 „
Lacerated wounds	7 „	1 „	6 „
	72	36	36

Of these 50 were of the heart and 22 of the pericardium.

I. *Of the Heart.*

Punctured wounds 10	Needles	8 cases
	Stilet	1 „
	Thorn	1 „
Incised wounds 30	Knife	10 „
	Dagger	7 „
	Poniard	2 „
	Bayonet	1 „
	Uncertain	10 „
Gun-shot wounds 7;	in 4 balls left in.	
Lacerated and ruptured 3		
50		

II. *Of the Pericardium.*

Incised wounds 13	Knife	5 cases
	Dagger	4 „
	Poniard	1 „
	Bayonet	1 „
	Uncertain	2
Gun-shot wounds 5;	in 1 ball left in.	
Lacerated and ruptured 4		
22		

The treatment will be mainly directed to prevent and arrest internal hæmorrhage, by absolute repose, local and general employment of cold, and early venesection to relieve the heart; and to allay the excited action of the heart by the administration of belladonna and digitalis internally. Where blood has become effused into the pericardium, it has been suggested to lay open the pericardium, and evacuate the blood and coagulated mass, and thus relieve the oppression of the heart; but although this has been recommended, it has not yet been put in practice, probably owing to the difficulty of distinguishing internal hæmorrhage into the pericardium from hæmorrhage into other important cavities.

Paracentesis of the pericardium is seldom called for; it has been performed between the fifth and sixth intercostal spaces, between the ensiform cartilage and the seventh rib, and by means of trephining the sternum. The operation is best performed in the fourth or fifth intercostal space, either by direct puncture or by incision and subsequent puncture, as in paracentesis thoracis: the precautions and mode of performance are the same.*

3. *Wounds of the vessels of the thorax.*—Wounds of the intercostal artery are occasionally met with; thus the vessel has been injured in the unskilful performance of paracentesis, and in the making of incisions into the chest without due anatomical knowledge; an intercostal artery has likewise been wounded in cases of fractured ribs, and in penetrating wounds of the chest. The effects will be either external or internal hæmorrhage. The symptoms of internal hæmorrhage have been already detailed at p. 590, to which reference must be made. This occurs generally in cases of punctured wounds or stabs, where the blood, not being able to escape externally, passes into the pleural cavity. Where the hæmorrhage takes place externally, in consequence of a large and direct wound, a pulsating jet of arterial blood may be observed, which will immediately apprise the surgeon of the nature of the injury; but, generally speaking, the wound is small, and the blood escapes continuously, and not *per saltum*, so that much is lost before the means of checking it can be had recourse to. Sometimes the blood, instead of escaping externally, passes into the tissues external to the chest, as in a case related by Mr. S. Cooper.† A young gentleman had been wounded by a

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* See *Clinical Lecture* by Trousseau, the *Clinique de l'Hôtel-Dieu*, vol. i.; also Mr. Wheelhouse's successful case in the *Medical Times*, Nov. 3, 1855, and Dr. Allbutt's 'Clinical Lecture,' *Lancet*, June 12, 1869.

† *Surgical Dictionary*, p. 1,491, 7th edition.

penknife, severing an intercostal artery about two inches from the vertebral column; about eight ounces of blood immediately flowed from the external wound, followed by an enormous extravasation of blood under the muscles of the back, intense pain, and high symptomatic fever. In a few days, in consequence of suppuration having taken place, an opening was made, and about a gallon of fluid was discharged, composed partly of pus, but chiefly of putrid blood. The case proved tedious in consequence of the formation of deep sinuses, and life was frequently in great danger; but in the end the patient recovered. It has been suggested, in order to facilitate the diagnosis, to introduce into the wound a piece of card, which will allow the blood to flow out externally along its surface, if the artery be wounded, and internal hæmorrhage be suspected.

The treatment of wounds of the intercostal artery will be the enlarging of the external wound, and securing the divided ends of the artery by ligature; but this is by no means easy.

Mr. Harrison, in his well-known work *On the Arteries*, thus alludes to this point: 'In cases of wounds of the thorax, in which an intercostal artery has been opened, the patient may lose a considerable quantity of blood before the surgeon can stop the hæmorrhage; the artery lies so deep, and the intercostal space is so confined, that it is almost impossible to hold the artery with the tenaculum or forceps, for the purpose of applying a ligature upon it. The student may form some conception of the difficulty of this operation if he expose an intercostal artery in the dead subject, by dissecting from the surface. This may also lead him to reflect upon the plans which have been proposed for securing this vessel where a ligature cannot be directly applied; he may endeavour to pass a small curved needle round the artery, directing it from within outwards; and should this measure be attended with much difficulty, from the smallness of the incision, he may observe how much it will be facilitated by enlarging the opening. Suppose it were impracticable to pass a ligature round the artery in the living subject, he may learn from his dissection the possibility of compressing it by other means; thus, by placing a ligature on a piece of sponge, and introducing the latter through the wound into the chest, then withdrawing the ligature so as to cause the distended sponge to make pressure of the vessel against the rib, and securing the thread externally over a compress placed over the wound, he may by these means restrain the bleeding.'

A variety of methods have been suggested, such as the passing of a ligature or wire around the rib, so as to include, not only the artery, but also the bone and soft parts; the introduction of metal or ivory plates into the chest, drawn from within outwards by means of riband or silk thread, so as to compress the artery against the rib. All these methods are unjustifiable, as they are liable to excite severe inflammation of the pleura and lung. Assalini* prefers simply cutting the artery across, so as to allow it to retract; and if this plan fails, he recommends the wound to be closed; should the blood find its way into the chest, it is true the consequences will be serious, but not fatal; and if the symptoms require it, the operation for empyema may afterwards be performed. A small quantity of effused blood, however, may be absorbed, and no such proceeding be requisite.

Dr. Hennen† says: 'Unfortunately, we but too often are disappointed in finding the source of the hæmorrhage, and here judicious pressure is our only resource. In some very slight cases I have used the graduated compress with success; but if the sloughing is extensive nothing but the finger of an assistant, relieved as occasion may require, and pressure directed upon a compress placed along the course of the vessel, or so disposed as to operate upon its bleeding orifice, will be of any avail.'

Wounds of the internal mammary artery.—The protected situation of this vessel renders its injury exceedingly rare; still there are several cases on record. M. Tourdes has written a special monograph on this accident in its medico-legal aspect: the result he arrives at is, that the lesion occurs on the right and left sides in equal proportion; that in more than half the cases it is accompanied with section of the cartilages, and that this section always exists when the vessel is wounded below the fourth rib: he also remarks that all wounds situated at the sides of the sternum from the first to the seventh ribs, and of sufficient depth, should always engage our attention, and be regarded as suspicious.

The results may be: 1, external hæmorrhage; 2, hæmorrhage into the anterior mediastinum; 3, hæmorrhage into the cavity of the pleura; 4, hæmorrhage into the cavity of the pericardium; besides, the injury is not unfrequently complicated with wound of the lung, heart, or diaphragm.

The symptoms will be those of hæmorrhage, in addition to those of any complication which may exist.

The prognosis is always unfavourable; much internal effusion of blood takes place, and death generally ensues from the hæmorrhage.

The treatment consists in compression of the vessel in the same way as above prescribed in wounds of the intercostal artery, and in the application of a ligature on the vessel; although this latter proceeding is exceedingly difficult. In the first three intercostal spaces the artery may be secured with ease; in the fourth space it becomes difficult to reach; the operation is very difficult in the fifth, and almost impracticable in the sixth space. It is performed by making an incision for two inches along the side of the sternum, and in an oblique direction from above downwards, and from without inwards, forming with the axis of the body an angle of forty-five degrees; the centre of the incision to be three or four lines from the border of the sternum. Having divided the skin, cellular tissue, and origins of the pectoralis major muscle, the intercostal space is brought into view; the intercostal muscle is now to be carefully divided upon a director, and the edges drawn apart by retractors, when the artery becomes exposed.

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* *Manuale di Chirurgia*, pp. 58, 59.

† *Military Surgery*, p. 377, 2nd edition.

Baron Larrey* says that he has seen several cases of wounds of this vessel, and he proposes simply to close the external wound so as to allow of coagulation, and by this means to compress the vessel. He relates three cases of this injury. The first case was a sabre-thrust, which entered the chest for an inch and a half, dividing the cartilage of the seventh rib close to the sternum; there was great effusion of blood, and very severe symptoms, so that it was thought necessary to lay open the wound and evacuate the blood; the man made a good recovery. In the second case, a knife entered above the cartilage of the fifth rib on the left side; the wound was closed, much effusion of blood followed, and severe symptoms set in, so much so, that a puncture was obliged to be made, whereby a pound of blood and clot was evacuated; but the patient lived only twenty-one days. In the third case a knife entirely divided the cartilage of the fourth rib; this was followed by much hæmorrhage, which ceased, and the wound was closed; in a few days signs of internal hæmorrhage ensued, paracentesis was performed, two and a half pounds of blood evacuated, and a recovery resulted.

Some years ago, a man was admitted into the Meath Hospital, having received a stab of a sharp-pointed shoemaker's knife, about one inch below the right sterno-clavicular articulation, by which the internal mammary artery and vein were wounded. These vessels poured out their blood continually, and in such abundance into the cavity of the pleura, that the lung became dreadfully oppressed, and it was deemed advisable to perform the operation of paracentesis on the fourth or fifth day after the injury. A large wound was made in the operation, in the expectation that it might facilitate the escape of any coagulum, but the precaution was found to be unnecessary, as the blood had remained in a perfectly fluid state, and flowed away with great facility. The quantity of blood thus lost was enormous—it must have amounted to some quarts; and as the wounded vessels still continued to bleed, it is scarcely necessary to add that the patient soon died.†

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* *Clinique chir.* t. iv. p. 101.

† Porter *On Aneurism,* p. 170.

Wounds of the larger vessels of the chest are for the most part fatal, and are attended with all the symptoms of rapid internal hæmorrhage, death almost invariably resulting immediately, or in a few hours afterwards. Some rare cases of survival after such wounds are, however, on record; thus Dr. Heil* details a case in which a patient recovered and lived for twelve months after receiving a stab which penetrated the ascending aorta.

Pelletan† writes: 'In May 1802, a young man was brought to the Hôtel Dieu, who, in a duel, had been run through with a foil, which entered above the right nipple and came out at the left loin; the most alarming symptoms were apprehended, but several days elapsed without any serious complaints taking place. The patient was bled twice, and kept on very low regimen. Everything went on quietly for a fortnight, when he began to complain of severe pain in the loins, which was relieved by the warm bath. He seemed to be recovering; he got up, and went to walk in the garden allotted to the sick, but the pain in the loins quickly returned, attended with difficulty of breathing, with constipation, and wakefulness. He became now very impatient and out of temper at not being relieved. On July 15, two months after the accident, there was remarked a deformity of the spine, about the eighth dorsal vertebra. The patient grew rapidly worse, and died in the utmost agony, saying that he felt suffocated; and tore off his shirt, so that his chest might be free from pressure of all kind. On the body being opened, the right side of the chest was found full of blood, coagulated in various degrees; and an opening, the diameter of which was equal to that of a quill-pen, was detected in the aorta, above the crura of the diaphragm. All the adjacent cellular tissue was injected with blood, and three of the dorsal vertebræ were found carious. There was no mark of injury perceptible in any of the thoracic or abdominal viscera.'

Breschet‡ relates the case of a wound of the vena azygos, a little below its entrance into the superior cava, which was followed by considerable effusion of blood, and death resulted on the third day from compression of the lung by the effused blood.

4. *Wounds of the œsophagus.*—These are, for the most part, complicated with other injuries, and are more appropriately treated of with wounds of the neck. However, it has been considered advisable to draw attention in this place to wounds of the thoracic portion of the œsophagus, by referring to the following case.§

A man, aged twenty-four, was stabbed by a bayonet in the anterior and superior part of the chest; it entered between the third and fourth right ribs, one inch from the sternum. He fled from his assassin for half a mile, without feeling any pain; on reaching home he had coughing and spitting of blood, and in an hour after the accident experienced inexpressible anguish; he was lying on his right side, suffering from the least movement, and complaining of intense pain all along the right side of the chest, as far as the haunch. At each inspiration and cough, air escaped through the wound, sufficient to blow out a candle seven or eight inches distant. On the second day, respiration was much embarrassed, but the spitting of blood was arrested after a third venesection. On the third day, on removing the dressings there escaped a large quantity of red fluid, of less consistence than blood; the respiration was more free. Much fluid ran out during the day, and at each time of dressing, and it was suspected to be the fluids swallowed. Oily and coloured drinks were given, which in due time stained the dressings. The patient was now prevented taking anything by the mouth, and was fed by nutritious enemata. For four days nothing escaped through the wound, and he made a gradual recovery. Subsequently he had signs of a large effusion in the chest, when on the thirtieth day he vomited and rejected a large quantity of pus; this flow of pus lasted for another fifteen days. He ultimately recovered.

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* *Henke's Zeitschrift,* 1837, t. ii. p. 459.

† *Clin. chirurgicale,* t. i. p. 92.

‡ Op. cit.

§ Boyer, *Traité des Maladies chir.* tom. vii. p. 220.

Foreign bodies have passed down the œsophagus and escaped through its parietes into the chest; several cases of the kind are recorded by Fischer, and are referred to in the table on p. 602.

Contusions of the chest, followed by lesion of the contents without any external wound, may be associated with the following effects: firstly, pleurisy, and in rarer instances pneumonia, which come under the more immediate cognisance of the physician: secondly, inflammation of the cellular tissue of the mediastina, running on to suppuration, and producing dyspnœa from pressure on the lung, or causing disease of the sternum, in rare instances assuming the form of a pulsating tumour, owing to the contiguity of the heart, and simulating aneurism.*

Thirdly, such contusions may be attended with rupture of the lung; this last accident is rare, but several well-authenticated instances are on record. The symptoms, diagnosis, prognosis, and treatment will be the same as detailed in wounds of the lung, but in these cases there will be an additional obscurity, viz. the absence of any external lesion, or fracture of the ribs.

Watson, in his work *On Homicide,* relates the case of a carter, who, being somewhat intoxicated, was thrown off his cart, and the wheel passed obliquely over his chest; he expired shortly after. There was no external wound, and no fracture of the ribs; but a laceration of the right lung near to the origin of its vessels, and there were three pounds of blood in the right cavity of the chest: the liver was also lacerated, and blood effused in the abdomen.

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* Sir A. Cooper mentions the case of a medical student who was supposed to have aneurism, but matter made its way through the sternum, and a thorough recovery was effected.

M. Gosselin, in *Mém. de la Soc. de Chir. de Paris*, vol. i., has fully entered into this subject, and adduces two cases of ruptured lung from violence, without any external wound or fracture of the ribs, both of which recovered: he remarks that when a rupture takes place, there may be a solution of continuity of the pulmonary vesicles without wound of the pleura; or there may be a tearing of the lung-tissue, as well as of the pleural envelope; in the latter instance, air and blood will escape, and the symptoms will be those of hydro-thorax; there will be dulness at the lower part of the chest and sonority at the upper part, a mucous râle or gurgling opposite the site of the rent, metallic tinkling, dyspnœa, frequent respiration, spitting of blood, and sometimes cutaneous emphysema.

In the *British Medical Journal* for March 1859, there is related the case of a boy, aged seven, who was struck down by a cab, the wheel passing over his chest. He complained of great pain in the belly and on the left side of the chest, which was dull and gave no evidence of respiratory murmur. About four hours after, there was considerable distension of the intercostal spaces, and great dyspnœa; he died on the following day. The ribs were found uninjured, but the lung was extensively lacerated, and the pleural cavity full of blood.

A similar case occurred at Guy's Hospital, but death ensued in two hours, in consequence of the complication of ruptured liver; the lung was ruptured at the lower edge of the middle lobe of the right side, to the extent of three inches; the pleural cavity was filled with air and some ounces of blood, and the lung partially collapsed.

A third case is recorded by Dr. R. B. Donnell, in the *Dublin Quarterly Journal*, vol. xxxviii. p. 205. It was that of a young man, aged twenty-four, who lived ten days.

Pneumonia or pleurisy may supervene. The prognosis is unfavourable, as the laceration is generally extensive; still, death is not always the result, as seen by the recovery of the cases brought forward by M. Gosselin.

The rupture may be direct, viz. at the seat of injury, or indirect, at some distance off; and M. Gosselin asks, how are we to explain the rupture of the lung without any fracture of the ribs? Is it from shock, as is observed in injuries of the brain? He thinks not: the elasticity and mobility of the ribs are too great, and they resist such shock, without implicating the lung-tissue. Again, is it from extensive and long-continued pressure of the ribs forcing the lungs against the spinal column?

The lung is spongy, soft, and composed of cells freely communicating with the bronchi and trachea, and, when compressed at one part, the air escapes into another; and thus the lung accommodates itself and does not tear: on the other hand, in order to press the lungs against the spine, there must be enormous force and pressure; and even then it is impossible without fracture of the ribs.

M. Gosselin offers the following explanation as to the probable cause:—that at the time of the injury, when the chest receives the violence, the lungs are suddenly filled and distended with air by a full inspiration, and the air, prevented from escaping by occlusion of the larynx, thus becomes pent up in the lung-tissue, and the lung not being able to recede from the superincumbent pressure, its tissue necessarily gives way.

Fourthly, severe contusions of the chest may be followed by cerebral congestion, owing to derangement of the circulatory and respiratory functions; thus, heavy weights falling upon the chest, or undue and prolonged pressure on the ribs, preventing their free action, as in the fall of earth whilst excavating, may arrest the respiratory functions and induce venous congestion and asphyxia. There may be in consequence epistaxis, ecchymosis of the eyes, congestion of the brain, &c.

Fifthly, contusions may give rise to pericarditis and carditis, as evidenced in the following instances:

A child received a blow on the chest, causing great pain and very violent palpitation; he had repeated attacks of hæmoptysis, and died at the end of six months. There was pericarditis and carditis, and a livid sphacelated spot on the heart, which extended into the cavity of the ventricle.

Blancard* relates the case of a peasant who was thrown under a cart; he had immediate pain in the chest, and dyspnœa, with a feeling of compression of the heart; after four days he went to work, but soon after had violent fever, oppression, and delirium, with insomnia, extreme thirst, and frequent syncope. He died on the eleventh day. The pericardium was full of sanious pus, and the parietes of the auricles, here and there, ulcerated and softened.

Sixthly, contusion of the chest may be complicated with injury to the heart, causing a rupture of its fibres or its valves. The symptoms and prognosis will be the same as those detailed in Wounds of the Heart. Death, however, in these cases, is almost always instantaneous, although some have lived for several hours. There is a preparation of a lacerated heart of a child in the Museum of the Royal College of Surgeons, Edinburgh;[*] in the description of which it is stated that a cart-wheel had passed over the chest and occasioned instant death, but there was no external wound or fracture of the ribs. Dr. Christison[†] mentions two cases from violence, the one caused by a fall, the other owing to a blow. Mr. Gamgee[‡] has collected 27 published cases of the kind; 12 occurred on the right side, of which 8 had rupture of the ventricle, and 4 of the auricle; 10 occurred on the left side, of which 3 were of the ventricle, and seven of the auricle. In half of the cases the pericardium was intact.

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* *Lexicon Med. Renov.* 1735.

For further information see Fischer's work on the subject.

ALFRED POLAND.

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[*] See *Trans. Edin. Med.-Chir. Soc.* vol. i.

[†] Watson *On Homicide,* p. 96.

[‡] *Researches in Pathological Anatomy and Clinical Surgery,* 1856.

INJURIES OF THE ABDOMEN.

INJURIES of the abdomen are accidents generally of a grave character, with the effects of which the surgeon has frequently, but too often hopelessly, to combat. To ensure a careful and a comprehensive examination of the nature and the results of these injuries, it is intended to consider the following points:

a. Contusion of the parietes.
  1. Without rupture of viscera.
  2. With rupture of viscera.

b. Wounds.
  1. Wounds of the parietes without protrusion of viscera.
  2. Wounds with protrusion of viscera.
  3. Wounds of viscera.
  4. Fistulæ; gastric and biliary.
  5. Artificial anus.

c. Foreign bodies in
  1. The stomach.
  2. The intestines.
  3. The cavity of the peritonæum and in the abdominal wall.

CONTUSIONS.

Contusion of the parietes of the abdomen, without rupture of any of the abdominal viscera, may prove, according to the violence of the injury, of serious importance, or trifling in effect. But even a slight contusion of the abdominal wall must not be regarded too lightly. A very slight blow on any portion of it may produce symptoms sufficient to excite alarm, or demand most careful consideration in treatment; and therefore in any case of a blow or other violence received on the abdominal wall, the examination of the patient should be conducted with extreme caution and judgment, in order that the *utmost* amount of mischief that may possibly result from such an accidental cause should not be overlooked. In such an examination it should ever be borne in mind, that the previous general condition of the part injured will, to a certain extent, influence the results; and that in judging of these results we must look to many relative circumstances: whether the abdomen be thickly covered with fat, or diminished in size by general emaciation; whether the contents of the stomach and intestines be considerable in quantity, or whether the accident has occurred some hours after a meal. These and other circumstances should be fully inquired into, and considered, before we decide on the probability, as well as on the extent, of deep-seated mischief. Nor will it prove a small satisfaction if we can arrive at something like a favourable conclusion that the bruise of the integuments is not attended by rupture of any viscus.

Contusions of the abdominal wall (in which term we include merely the soft tissues surrounding the cavity of the abdomen) are various in their primitive, as well as in their subsequent, conditions. Such contusions are usually the result of falls or blows on the abdomen; of cart-wheels passing over the body; of shafts of carts or carriages forced against it; or of a quoit or cricket-ball striking it. Such accidents will frequently be immediately followed by intense pain, faintness, and vomiting, without any injury having occurred to the deeper tissues.

A quoit, in falling towards the ground, accidentally struck a boy on the epigastrium. The pain immediately experienced was agonising for some seconds, and was attended by great difficulty in breathing. The boy was very faint subsequently. Rest on a sofa for the afternoon was the only treatment adopted, and on the following day he appeared quite well, nor did any ill effects ensue.

There appears to be a prevalent and a rather popular idea, that *sudden* death may result from a blow on the epigastrium or abdomen, without any injury of structure, external or internal, being detected on examination after death. It is therefore very desirable to inquire if any evidence we possess justifies us in accepting the statement, that death may follow *immediately* upon a blow, without any actual appreciable alteration or injury of parts contained within the cavities of the abdomen or thorax. It is not disputed for a moment that a very violent concussion of the abdominal viscera may be *rapidly* followed by death; but a very violent concussion would act, not only as a *shock* to the nervous system, but would also, without doubt, produce marked evidences of injured tissues, readily recognised on examination after death. But are there not cases of sudden death reported to have followed blows on the abdomen, in which cases no evidence of altered tissue nor any indications of bruise could be found? This question we fear we cannot answer quite satisfactorily. 'There is no medical doubt that a person may die from what is termed shock,' says Dr. Taylor, 'without any marks of severe injury being discovered on the body after death. We have examples of this mode of death in accidents from lightning, or from severe burns or scalds, in which the local injury is often far from sufficient to explain the rapidly fatal consequences. As instances of this form of death from violence may be also cited those cases in which a person has been suddenly killed by a blow upon the upper part of the abdomen or on the pit of the stomach, which is supposed to operate by producing a fatal impression on the cardiac plexus. Whether this be or be not the true explanation, the fact itself is undisputed; it is certain that a person may die from so simple a cause without any appearance being produced, externally or internally, to account for death. On the skin, there may be some marks of abrasion or slight discoloration; but, as it has been elsewhere stated, these are neither constant nor necessary accompaniments of a blow. Convictions for manslaughter have taken place when death has been produced under these circumstances.'*

In confirmation of these remarks, Dr. Taylor refers to a case reported by Mr. Wood, of Bury, Lancashire, in vol. xliv. p. 213 of the *Medical Gazette.* We have copied the general particulars of this case, that our readers may draw their own conclusions respecting it. 'On the evening of July 6, 1849,' writes Mr. Wood, 'I was called to see David Bates, æt. 31, who had suddenly fallen in the street whilst fighting. I found him dead, and ascertained that about a quarter of an hour had elapsed since he fell. He was warm, and covered with perspiration; his face pale and cadaverous; his eyes closed, the pupils widely dilated.'

Nineteen hours after death, Mr. Wood made an examination of the body, of which the following are the notes.

'*External appearance.* Escape of bloody serum from the nostrils; black ecchymosed patch on the bridge of the nose; contusion under the right ear; slight lividity on the upper part of the chest; contusion on the left elbow. On turning the body on the face, about an ounce and a half of dark grumous blood escaped from the nostrils.

'*Abdomen.* Old adhesions of the omentum in the right iliac region; arch of the colon rather dark; stomach contained some half-digested matter, and presented numerous ecchymosed points in the mucous membrane of the posterior surface at the cardiac extremity; liver rather small, and presented a slightly mottled appearance on the surface; kidneys, spleen, and pancreas healthy.

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* *Medical Jurisprudence*, p. 299; 1858.

'*Thorax.* The lungs collapsed on opening the chest; were rather darkly mottled, but healthy; congested posteriorly. Old adhesions between their posterior borders and pleura on each side. Heart, healthy; contained very little blood, which was fluid. The blood generally in a fluid condition.

'*Head.* Dura mater slightly congested. *Pia mater on the surface of the brain and in the sulci between the convolutions excessively congested with dark fluid blood.** No fluid in the ventricles. Substance of brain healthy, and without any lesion.

'At the inquest, three witnesses stated that Bates was intoxicated, though not so much so but that he could walk and stand unsupported by others,—that he talked a good deal and challenged his antagonist to fight; that in two or three minutes, the combatants being within half a yard of each other, Bates received a *left-handed blow, but apparently not a severe one, in the pit of the stomach;* that he fell on his face, according to the first witness, within half a minute; according to the second witness, in a moment or two; according to the third witness, instantly, dead. The first two witnesses also swore that, in their opinion, he moved his arms in a fighting attitude after being struck, and before he fell; as they thought, with an intention of continuing the fight. The third witness, however, swore that there was no action of this kind. On raising him from the ground, which was done immediately by the witnesses, a few drops of blood escaped from his nostrils, but he was dead; and all the witnesses agreed that no indication of life was observed in him after he fell. On being asked to give my opinion as to the cause of death, I stated that, inasmuch as the post-mortem appearances did not furnish any other explanation, I unhesitatingly attributed it to concussion of the solar plexus, occasioned by the blow, which, according to the evidence of the witnesses, Bates had received in the epigastrium.' Mr. Wood further states, that Mr. P., a medical gentleman associated with Mr. Wood in making the post-mortem examination, who also heard the general evidence, stated: 'The condition of the membranes of the brain proved a great amount of excitement, and that this alone might have been the cause of death.' The jury, having heard conflicting medical opinions, gave the benefit of the difference of opinion to the prisoner, and returned as their verdict, that Bates died from over-excitement. Mr. Wood adds: 'The opinion expressed by Mr. P. appears to me inconsistent with all medical experience. I think all experienced pathologists admit that, in cases where sudden death from violence or accident occurs to an intoxicated person, it is usual to find the pia mater turgid with dark fluid blood, as was observed in this case. This at once disposes of the only appearance existing in the body on which Mr. P. could ground the opinion he expressed. There was no evidence adduced of any extraordinary excitement in Bates previous to fighting; he was drunk and quarrelsome, but showed no symptoms of oppression of the brain. He fell immediately after receiving a blow in the epigastrium; and the manner of his death, that is, the instant extinction of life, does not accord with our experience of death occasioned by any form of apoplexy, an attack of which coincident with the blow, though quite within the range of possibility, might fairly be considered very remarkable. I regard the case as an unequivocal instance of death from a blow on the epigastrium.'

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* The italics are ours throughout.

Before expressing any opinion on the observations of Dr. Taylor, or upon the latter case and Mr. Wood's remarks upon it, attention must first be drawn to the following extract from a prize-essay ' On Wounds and Injuries of the Abdomen,' by Mr. Alfred Poland, to whom the author is greatly indebted for the privilege of having been allowed to make use of this valuable manuscript:

'The epigastric and upper part of the umbilical regions contain such numerous and such vital structures, and above all, the solar plexus and its numerous branches, of such high organic importance, covered in by soft parietes little capable of resisting and transmitting external shocks, that it is not to be wondered at that death should be an immediate result of a blow in these regions.

'On inspection of such cases, no appreciable morbid changes can be detected, not even the trace of ecchymosis about the parts.

'A blow on the pit of the stomach—a hit in the wind, as it is called—does not act so much on the diaphragm as it does upon the nerves: occasionally, though not always, there is intense pain; but sometimes the shock is so severe as at once to arrest the action of the heart, and the man is killed as it were with a blow even of a trifling kind. Sir A. Cooper used to state a case which came to his knowledge, though he was not an eye-witness of the occurrence. Two men were working near the East India House, one of whom had a heavy load which he was wheeling along; his comrade said to him, "That is too much for you; stand aside, and let me—a better man—take it." He accompanied this with a slight blow on the scrobiculus cordis, and the man immediately let the barrow fall from his arms. He felt a severe shock; the sudden impulse made so strong an impression on the heart's action as to stop it, and, without complaining of pain, the man died on the spot. On examination, no lesion was discovered. In a case of manslaughter tried at the Central Criminal Court in August 1841, death had been caused in this way during a pugilistic combat. The man received a blow on the stomach, and fell dead. As there were no marks of external injury, the surgeon thought the man had died of apoplexy. In the latter of these cases there is no detail of the post-mortem examination to enable us to arrive at a satisfactory conclusion. Another case, somewhat more conclusive, but complicated with pregnancy, occurred in March 1835, and was the subject of a trial on the Norfolk Circuit, at Cambridge. John Bond was indicted for the murder of his wife by beating her with a codfish. The prisoner, who was intoxicated, desired his wife to cook the fish, which weighed about six pounds. She refused, because it was not a seasonable hour, and there was no fire. He seized the fish, and then beat her over the abdomen for some minutes with extreme violence. She died in a short time afterwards; and on a post-mortem examination the marks of many bruises were found on the body. The deceased was in the last month of pregnancy, and, in the opinion of the practitioner, her death was occasioned through the shock imparted to the system by the violence of the prisoner.'*

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* 'On Wounds and Injuries of the Abdomen, prize-essay, by Alfred Poland, Esq.

The cases related by Mr. Poland to illustrate the theory generally received as to the nature of these accidents are only three in number. No one acquainted with Mr. Poland's industry can suppose that he would have overlooked records of such a class of interesting cases, had there been many reported; and all who are acquainted with the rich stores of information contained within the case-books and museum of Guy's Hospital, as well as the immense practical experience afforded, in the course of years, in its wards, will feel satisfied that had such accidents, illustrating the theory advocated heretofore, been of even occasional occurrence, Mr. Poland would have had opportunities himself of recording several such facts. The case related by Sir A. Cooper proves nothing in illustration of the theory: the blow could not have been of a severe character; but had it been so, it does not follow that the blow, independent of existing disease, occasioned death. It is stated that 'the sudden impulse made so strong an impression on the heart's action as to stop it, and, without complaining of pain, the man died on the spot.' This statement, it appears to the author, should be received with some degree of caution; for it is doubtful whether the poor fellow was seen by any medical man until some time after death; and we would ask whether death may not equally be attributable to disease of the heart, and that the over-exertion of wheeling a barrow too heavy for the physical powers of the man immediately produced that death? Such an exertion would be more likely to excite undue action of the heart, and faintness, than the blow given by the companion. The particulars of the case are by no means satisfactory. Nothing certain can be deduced from the short note relative to the post-mortem examination. We are well aware that in such examinations, in past years, exact pathological conditions were not appreciated as they are now, and that many times deaths were apt to be attributed to accidents or insufficient causes, which in our days would be demonstrated to depend on actual disease.

In the second case there is nothing to justify an inference that the blow caused death; and the cause of death, as described by the medical man who saw the case, in no way confirms such inference. Men engaged in pugilistic encounters may possibly die from exhaustion; and death in such instances may more reasonably be attributed to a *series* of blows, and the exhaustion produced by the exertion entailed by fighting, than ascribed to *one* blow unattended by organic lesion.

The last case mentioned by Mr. Poland does not at all bear on this subject. Many bruises were found on the body. Many blows received from any heavy weapon or instrument, by a person in an advanced state of pregnancy, might readily produce such an amount of exhaustion as to be followed by death in a very short period; but neither this case nor the two preceding appear to the author to sufficiently bear on the point, that a blow on the abdomen or epigastrium will produce *sudden* death, without the existence of some severe organic lesion to be found on post-mortem examination.

In Sir A. Cooper's case, the evidence of the amount of violence is unsatisfactory; the minutes of the post-mortem examination are wanting: Sir A. Cooper himself did not see the case; the evidence on his part is second-hand, and would not be admissible in a court of justice, nor should it be admissible in a scientific inquiry.

In the second case, the exhaustion from fighting must be considered to have had a large share in hastening death, and therefore the latter cannot be attributed to one blow: but if so, there is no proof that organic lesion of the abdominal viscera did not exist.

The third case requires no recapitulation; it cannot even be classed among the list of *sudden* deaths, as the woman is said to have 'died in a short time after' she received the injuries.

With respect to the evidence adduced in favour of sudden death in Mr. Wood's case, it must be allowed that such evidence is entitled to great consideration; but there are circumstances in this case which should be weighed carefully, for no satisfactory conclusions can be arrived at from the report of one solitary example. In the first place, the man had been fighting some minutes; the perspiration on the forehead proved much exertion, this exertion supervening on a state of intoxication: the bruises on the body proved that the man had been '*punished*' previous to the blow on the epigastrium, which, in addition to the exertion of fighting, and the state of intoxication, formed three elements in favour of physical exhaustion. Then the results of the post-mortem examination of the head rather strengthen the supposition that the condition of the pia mater, his previously intoxicated condition, the various blows received in fighting, and the physical exhaustion from the mere exertion of fighting in an inebriated state, with a consequently excited brain, all combined to produce death. The state of the stomach rather indicated the effects of alcohol. In death from alcoholic drinks, Dr. Taylor states that 'the brain is found congested, and in some instances there is effusion of blood;'* and it will certainly be admitted that in a state of inebriety, violent physical exertion entailed by a pugilistic encounter would greatly add to an already congested condition of the brain, and at the same time produce more rapid exhaustion of the vital powers than would be the case in a condition free from the noxious effects of spirits.

Still, it is due to Mr. Wood to state, that the case related by him comes near to a fair illustration of the statement and belief, that sudden death is produced by a blow on the epigastrium without evidence of organic lesion; though the author himself is nevertheless somewhat sceptical on the point that death can occur without any organic mischief resulting from the blow at the time. He has seen nothing to justify any other conclusion. After more than thirty years' experience of vast numbers of accidents admitted into St. George's Hospital, after ample opportunities of examining in the dead-house a very considerable variety of cases, after reference to all the post-mortem note-books accumulated for many years, and after inquiry among many trustworthy observers, he is unable to arrive at any other conclusion; and though he may have erred in this conclusion in the abstract, there can be no doubt that, as a general rule, *sudden* death attributable to a blow on the stomach or epigastrium must be a rare occurrence; and that medical men should be extremely guarded in ever offering an opinion as to the cause of death in such supposed injuries, without satisfying themselves, *by most careful and minute post-mortem investigation*, that no violence has been done to the viscera, either abdominal or thoracic.

But a very slight blow, without immediate evidence of internal mischief, may be followed by very severe and alarming symptoms.

The following case is a well-marked instance of such an occurrence. An old gentleman received a slight blow on the abdomen, accidentally, when turning in bed. He thought but little of the circumstance at the time, but a few days afterwards complained of pain on the right side of the umbilicus, accompanied by tenderness on pressure; with these symptoms commenced a sluggishness of the bowels; a few days subsequently, the pain having increased, a well-marked swelling was detected at the part to which pain was referred; and with this swelling entire stoppage of the bowels was established. In consultation with Dr. Ormerod and Mr. Wildbore of Brighton, the author saw the patient a fortnight after all action from the bowels had ceased. He had been most carefully watched by Mr. Wildbore, who had withheld all solid food, and allowed nothing but fluid nourishment. Leeches had been applied, and constant fomentation to the abdomen. The patient had taken small doses of blue pill, at intervals, for several days. The tongue was moist and rather white; the pulse quiet, skin cool, no vomiting or nausea had occurred. To the right of the umbilicus, there was a distinct deep-seated mass, conveying to the touch the impression of a portion of bowel matted together, and thickened by deposit of fibrine. Gentle pressure could be now borne better than a few days previously, but still produced some pain. On pressing the part alluded to, a sensation was conveyed to the hand as if flatus was moved by the pressure, and was heard apparently passing through a narrowed channel. Beyond these symptoms there did not appear to be anything really urgent; for although the bowels had not acted for a fortnight, they were not distended; in consequence, no doubt, of the very judicious treatment that had been pursued since symptoms of constipation had set in. Examination of the rectum proved the lower bowel to be empty. It was now decided that the small doses of blue pill taken twice a day should be continued; that epithems should be constantly applied to the abdomen; enemata be used occasionally, and solid food be strictly avoided. The patient had within the last few days been unable to retain injections.

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* Taylor's *Medical Jurisprudence*, p. 278.

The pain, tenderness, and swelling gradually subsided. A few days subsequently, the patient was moved from Brighton to Richmond, and bore the journey without any suffering.

On the twenty-eighth day of the constipation, he was again seen by the author, in consultation with Mr. Hills of Richmond. The patient was quite cheerful, his tongue clean, appetite good, and pulse quiet. The abdomen was not distended, pain had subsided, and the thickening about the right of the umbilicus had almost entirely disappeared. On examination of the bowel per anum, two or three small portions of fæculent matter were felt. Mr. Hills had observed the day previous that a very small thin portion of fæces, about the thickness of a clay-pipe stem, had come away after the administration of an enema. In consequence of the fæculent masses felt in the rectum, it was decided at once to inject a large quantity of warm water into the bowel. As soon as this had been done, the patient was requested to sit on the close-stool, and in a short time afterwards passed some two ounces of fæces, with the water just administered. The latter was now quite tinged with fæculent matter,—the first occasion on which this condition had been observed since the constipation had set in. He expressed intense mental relief at the improved features of his case, and from that day recovery rapidly took place. He lived several years after his recovery, and died from the effects of some cerebral mischief.

A boy was admitted into St. George's Hospital late one evening. He complained of great pain over the lower part of the abdomen, but no clear statement of symptoms could be obtained from him. The house surgeon, concluding that the bladder might not have been emptied, passed a catheter and drew off a small quantity of urine. When seen by the author the following morning, the boy's face was indicative of suffering; the brow contracted, the pulse quick and sharp. The muscles of the abdomen were resistant and hard and contracted; slight pressure produced considerable pain over the lower portion of the abdomen, especially towards the right side. There was evidently peritoneal inflammation, from some cause. After some questioning, the lad confessed to having been kicked on the abdomen by a boy, while at play, the afternoon previous to admission, and that much pain was experienced after the kick. The lad was averse to mention the circumstance when he got home, but the pain became so severe the following day, that he was kept in bed by his parents, and lastly brought to the hospital. Leeches were applied to the abdomen, followed by constant fomentations, and he was ordered small doses of calomel and chalk every four hours. The next day the pain was less, but the pulse quick, and tongue white and rather dry. The leeches were repeated, and the calomel continued. He steadily improved under treatment, and in a few days was convalescent. He soon left the hospital, recovered.

These cases of injuries to the abdomen followed by inflammatory peritoneal action are satisfactory instances of favourable termination.

The following case illustrates the more severe effects of peritonitis after an injury. A woman was admitted into St. George's Hospital in 1859, under the care of Mr. Johnson. She had been kicked on the abdomen by her husband, on the lower part of the left side. The kick was followed by excessive pain and general peritonitis. There was great and constant difficulty in procuring action of the bowels. The symptoms were treated by the application of leeches, fomentations, and the internal administration of mercury; but the tenderness and distension of the abdomen, constipation, and difficulty in passing motions, continued for some six months. The patient was greatly reduced, and when she left the hospital there was much distension of the abdomen, general pain on pressure, and an inability to move about with any degree of activity. The diagnosis was, that the bowels had become matted together to a great extent by adhesion of their peritoneal surface.

These cases prove that we may have to contend with severe symptoms produced by a comparatively trifling injury, and that we may find but slight ultimate mischief remaining subsequent to most alarming conditions.

Additional cases might be produced to illustrate these observations, but the relation of a greater number would not more clearly explain the practical results of such injuries; suffice it to say, that the slightest blow on the soft walls of the abdomen must always be considered with care, and treated with due caution; but that we must not look with despair on what may at first appear, from the severity of the symptoms, a most formidable injury.

Let us inquire what are the pathological conditions and consequences of a blow or other injury on the abdomen. External to the peritonæum, we may find—

1. Rupture of muscle.
2. Contusion of the soft tissues, with extravasation of blood.
3. Without the former, and without external wound, rupture of the peritonæum, and consequent extravasation of blood into the cavity of the abdomen.

1. Rupture of muscle is not often detected as a result of external violence to the abdominal wall, unless the accident prove fatal. Any direct blow may rupture the fibres of a muscle, without producing other injury; and the abdominal muscles are not exempt from this liability. The author was consulted by a gentleman suffering from an apparent rupture of the inner fibres of the recti muscles, about midway between the umbilicus and pubes. The injury was the result of a book falling directly on the abdomen, one corner striking the part affected. There were no severe symptoms immediately subsequent to the blow, but, after recovering from the first bruise, there remained an inability to perform many of the movements of the body, especially those in which the actions of the abdominal recti muscles are much called into play. In the recumbent posture on the back, the patient was unable to raise himself, nor could he do so without turning on one side—and with care only could he move; walking to any extent was followed by discomfort, and even pain in the region injured. The local conditions presented an evident separation, or want of muscular fibres, to the extent of about one inch and a half in diameter. The patient had suffered general inconvenience in movement, rather than any constitutional disturbance; and at the termination of twelve months after the injury, appeared little better able to take active exercise than he could a few weeks after the blow. It was not considered advisable to recommend more than caution in exercise, and a support to the abdomen, so as to restrict extension of the body, either sudden or beyond the upright position.

As the result of tetanic spasm, we have witnessed rupture of the broad muscles of the abdominal wall.

Mr. Poland has favoured the author with notes of two cases, in persons of advanced life, in both of which rupture of the rectus took place from the patients falling against their iron bedsteads in the wards of the hospital. In each instance, the patient had been suffering from severe illness; one from the effects of fever, the other from disease of the urinary organs, and both were at the time greatly reduced in strength.

Lagouest reports the case of a soldier, aged twenty-seven, who, while performing some gymnastic exercises, was attacked with severe pain in the abdomen, which increasing and being accompanied by swelling, he was taken to the Hospital of Val de Grâce. A little above the pubes, a hard, well-defined tumour was observed, not increased by coughing, and which followed the course of the right rectus, increasing in breadth towards the umbilicus. At the termination of a week only slight hardness remained. The case terminated favourably, with rest, regimen, and cold applications.*

The symptoms of ruptured rectus muscle may be judged of from the foregoing cases: pain, sudden in character, most probably attended by swelling, the result of effused blood, and probably indicated by a dent in, or by a marked separation of the torn ends of the muscle; pain, increased on motion, even to such an extent that movements of the body may be almost impossible for a time.

The treatment of rupture of any abdominal muscle, when such is suspected to exist, must chiefly consist in rest, and attention to position, so as to relax the injured muscle. The results are generally far from satisfactory, after the patient has recovered from the immediate effects of the accident; in all probability much weakness will be experienced in movements, at the injured part; and pain will most frequently persist, as a lasting evidence of permanently damaged tissue.

Another evil is very apt to follow upon the rupture of an abdominal muscle, however slight the injury may be, viz. that a hernia may present itself at the point of separation of the muscular fibres; and in most cases such a consequence may be anticipated. The coverings of such a hernia would be devoid of muscular fibres, and the contents would be little liable to strangulation, from the fact that the sac is devoid of a constricted neck. A large pad, with a bandage or truss, will be necessary in such cases for life.

We have not been able to satisfy ourselves that there is any foundation for a suggestion of Virchow, viz. that abscesses of the abdominal wall are frequently dependent for their cause on ruptured muscle.

Contusion of the external soft parts of the abdomen, with extravasation of blood into the cellular tissue, may be extensive; and will generally be indicated, more particularly a few days after the injury, by the usual ugly-looking patches under the skin, of blackish-red colour, which subsequently shade off into blue and green, and roughly mark out the extent to which blood has percolated into the surrounding structures. Associated generally with such extravasations, there will be indications of bruised muscle to some extent; the patient will complain of pain in movements; or even while resting quietly in bed, will experience a soreness, or discomfort in respiration. There need not be much cause for apprehension under such circumstances, provided no indications be present of *peritoneal* injury.

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* *Gazette des Hôpitaux*, 1860, No. 76.

When secondary inconveniences arise in cases of contusion of the soft tissues, they occur mostly in those instances in which *large* quantities of blood have been extravasated. Blood does not *then* become readily absorbed; and suppuration and abscess may be the result. The former will often become extensive, or the latter may form in very large collections of matter; and either may be very tedious in its progress towards reparation. The progress, however, will be slow or rapid, for good or for evil, according to the state of the patient's health and age. In an unhealthy condition of body, suppurative inflammation will generally be attended by much constitutional suffering; the integuments become inflamed, and often slough; or matter burrows in various directions, and requires constant watching, and early and ample exit: all which may, sooner or later, terminate in the patient's death, without having produced visceral complication. In old age, the skin is more apt to slough, or ulcerate if slightly bruised, and if undermined by much extravasated blood, the injury may rapidly prove fatal.

The *quantity* of the blood extravasated, quite as much as the direct *injury* to the soft parts, must weigh in the balance which determines the formation of an adverse or favourable opinion regarding the patient's future. Given the amount of the extravasation, we may almost foretell the progress of the case.

But a direct bruise may be followed by a slough of the tissues. This result, as a general rule, is not a common feature in such an injury to the abdominal walls. Usually, the apparent mischief to these soft parts is not very serious. Their peculiar attachments, their relative position to each other and to the viscera, render them capable of receiving pretty considerable pressure, without offering much resistance, and they may thus yield to and avoid the effects of compression, which would otherwise be sufficient to destroy their vitality at once, or materially interfere with it subsequently.

It is not common to witness extensive or serious contusion of the muscles and external soft tissues of the abdomen alone, short of more serious complications involving some of the viscera. So that our attention need not at present be directed to such contingencies, as the lesser evil would succumb, both in symptoms and in treatment, to the greater.

The treatment of bruises with extravasated blood in the walls of the abdomen is very simple, and should be similar in all essentials to the treatment of severe bruises of other portions of the trunk or limbs. The surgeon should ascertain, without delay, that the patient can pass water readily, and that there is no tinge of blood in the urine. The presence of blood generally indicates deep-seated extravasation and visceral injury.

Rest should be enforced in the recumbent posture, or, if the bruise be very severe, or the extravasation extensive, strict confinement to bed should be enjoined; fomentations should be applied constantly to the part, to relieve pain, and they much aid to soothe the soreness and lessen the stiffness and discomfort of the bruised tissues; the diet should be regulated according to the patient's powers and constitutional state.

In extravasations of blood from contusion of the parietes, our watchfulness should be constant whenever the extravasation is so great in amount and of such an extent as to occasion a prospect of suppuration. The circumstance of suppuration following upon such extravasations will be indicated at first by some, more or less, constitutional disturbance: slight blush commencing on the surface of the skin over the injured part; the swelling increasing in extent; the inflamed skin becoming shiny and tender to the touch. Should such evidences of commencing suppuration manifest themselves, the fomentations should be changed for poultices or lint and warm water under oiled silk. As the local mischief increases, the constitutional disturbance becomes aggravated; and unless the symptoms are relieved by the exit of the matter collected, they may become very alarming in character. The earliest opportunity to give escape to matter must be sought by the surgeon. A free incision, under circumstances indicated by the above severe symptoms, is soon followed by considerable local relief, and by a marked amelioration in the condition of the patient.

And now the treatment should be conducted on the same principles as in similar injuries of other parts. Especial care should be taken to prevent matter burrowing deeply, for the want of ready external outlets; and any reluctance in the wounds to heal should be suspiciously watched, and care taken that if any sinuses exist or ensue, they be laid open to the extreme extent of practicability and safety.

Abscess, the result of extravasated blood, following contusion of the abdomen, may prove a serious as well as a tedious matter, when pus collects and burrows in and about the region of the pelvis: nor can the surgeon be too circumspect or too energetic in his efforts to give an early and ample vent to purulent fluid, whenever a suspicion crosses his mind that matter is lodged anywhere in the neighbourhood of the original injury, and within reach of the knife. Months of suffering may result from any want of early care or prompt determination in the treatment of such a case; and it is no uncommon result, that a patient sinks after a long period of pain and suppuration, exhausted by the profuse drain on the system caused by the secretion of numerous and tortuous sinuses.

When suppuration has once commenced, and a free outlet is established, the patient should be supported by generous diet and a liberal allowance of stimulants. Frequently the drain on the system, when such accidents give rise to suppuration, is so considerable in amount that very large quantities of stimulating fluids may not only be taken with impunity, but are essential to the maintenance of life and to ensure recovery.

Our next point for consideration is, the probability and the effects of rupture of the parietal peritonæum, from a blow or external violence, without injury to the abdominal viscera. The question which may naturally be asked, is, whether such an injury can occur without the complication of visceral mischief? Experience answers that it is just possible occasionally; but that in the majority of accidents, in which violence is applied to any portion of the abdominal region, such a result is the exception to the rule. In most instances, the symptoms which present themselves barely justify a certain diagnosis, and in very few instances a difference in treatment from that necessary for injured viscera. That the peritonæum will not yield to sudden stretching as readily as some of the tissues which lie subjacent to it, is well illustrated by the fact, that rupture of the peritoneal covering of the uterus has taken place, while that viscus has remained entire: also, by the fact often observed in cases of enormous and rapid distension of the large gut, when it has been suddenly blocked by a twist, a tumour, or other mechanical obstruction, in which instances we have frequently found rents in the peritoneal coat alone, without corresponding rupture of the remaining coats of the bowel.

The following interesting case would rather fall into the category of rupture of the peritonæum, with subsequent and severe hæmorrhage. The author is indebted to his friend Sir R. Martin for the particulars. Two men were run away with in a gig, and one of them—healthy, and about twenty-five years of age—was thrown out with great violence, and fell from a height of many feet on a quarter-staff, which he had retained in his grasp—the one end of the staff having become fixed in the ground, while the other received the falling man upon his epigastric region. It was represented that the man was at once rendered insensible, and remained so for about an hour; soon after which he was seen in bed by Sir R. Martin. 'The countenance and general appearance had all the characters of the most fatal collapse of remittent fever, with the addition of urgent terror. There was the concentrated epigastric anguish, and the body was fixed and immovable; the abdomen being enormously tumid and hard as a barrel, the epigastric region intolerant of the weight even of the sheet. The pulse was not to be counted, and the skin was cold and damp. I considered the symptoms referable to both epigastric shock and hæmorrhage. The man was ordered diffusible stimuli, with small doses of calomel and opium, which were continued until the system was brought gently under mercurial influence. The patient recovered steadily and without accident.' Sir R. Martin's remarks at the conclusion of the case are worthy of notice: 'We can but conjecture,' he says, 'at the nature and extent of the injury in this case. My own view at the time was, that rupture of the peritonæum, with hæmorrhage, had occurred; certainly, I have seen men killed by blows, on the abdomen, of less violence than took place here. The anguish of both mind and body was greater than I remember ever to have seen, either in the collapse of remittent fever, or from wounds or accidents.

'A young officer of dragoons, who was shot in a duel, the ball passing right through the liver and spleen, suffered much anguish during two-and-thirty hours that he lived; but his sufferings were nothing as compared to those in the case above described. Indeed, I have never witnessed anything like them in severity, the patient recovering from the injury.'

It may, however, be objected that rupture of the peritonæum by sudden force can rarely, very rarely, occur without some laceration of the part which the injured membrane covered. And this no doubt is the fact in very many instances; but as the consideration of ruptured viscera will form a subsequent portion of this essay, the complications of visceral injury, in connection with simple rupture of the peritonæum, need no further mention here.

In the Museum of St. George's Hospital is a preparation* in which may be seen a laceration of the peritonæum covering the mesentery, the latter also being implicated in the laceration to the extent of about an inch; there were also to be seen several small accumulations of extravasated blood around the lacerated part. The injury occurred in a man who was kicked on an inguinal hernia; the protruded intestine was also ruptured at a point distant from the lacerated peritonæum and mesentery.

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* Series ix. No. 93.

Our diagnosis of the injuries already considered will depend on symptoms which, in some cases, will be immediate upon the injuries; and in others will not be evident until some time has elapsed. A blow upon the abdomen, though followed by much faintness, need not be necessarily otherwise than harmless in its effects; and it may be pronounced to be harmless, if the faintness be not lasting, nor followed by vomiting, or pain, or great anxiety, with disinclination to movement.

Provided there be no visceral complication in any instance of rupture of the parietal or visceral layers of the peritonæum, the *first* and *chief* danger to be apprehended from such an injury is hæmorrhage. If the rupture of the peritonæum be confined to any portion attached to the abdominal wall or diaphragm, the *probability* is that there will not be hæmorrhage to any alarming extent. But if the rent occur in a portion attached to a pregnant uterus, to the omentum, or to the mesentery, the probability is that hæmorrhage will be excessive, and it may prove fatal. Under these circumstances, there will be general blanching of the surface of the body, a cold clammy skin, anxiety of countenance, constant yawning, sensations of great distress and sinking, rapid pulse, and great restlessness in bed. In this latter respect there is a most marked difference in a patient suffering from ruptured viscera. He lies in a constrained, quiet posture, usually on his back; the muscles of his abdomen are tensely contracted. The patient with ruptured intestine complains of severe continued pain, always accompanied by vomiting, which is persistent and constant, and which nothing relieves; but with rupture of the peritonæum alone, followed by excessive hæmorrhage, whatever the amount of pain, vomiting may and will generally be entirely absent; and in the absence of pain, the patient's anxiety is solely referred to the extreme collapse, and he often expresses himself to be dying.

The course of such a case is run more rapidly than that of one with ruptured intestine without hæmorrhage. A few hours may terminate life, before any secondary action has had time to commence. It is the extent of extravasation, rather than the extent of laceration, which settles the rapidity of the case;—it is *that* alone, we may almost say, if the viscera be not ruptured, which calls for our utmost care, and aggravates our anxiety. Short of hæmorrhage, and short of ruptured intestine, a laceration of the peritonæum *need* not alone be fatal—probably *will* not be fatal. The conditions generally found after death, when hæmorrhage has been the fatal cause, are either rupture of the mesenteric vessels, or of the vena cava, or other large veins or arteries. The rupture of the larger vessels seldom is the result of a blow, but rather that of heavy weights passing over the body. The portal vein has been found ruptured previous to entering the transverse fissure of the liver, and without laceration of this viscus.

In the treatment of such injuries, no general law can be laid down, no canon can dictate our practice. Passing over those cases in which excessive hæmorrhage rapidly destroys life, and which admit of no beneficial or mitigatory treatment, let us look at such as may require the surgeon's care, and may be successfully managed. The cases which will demand, and will repay, the most careful watching—perhaps much active and assiduous attention—are those in which the injury is followed by peritonitis, either of a chronic or of an acute character. Such cases must be constantly, frequently, and most carefully watched during the early days after the accident; for it may well be laid down as a maxim, the truth of which we have already illustrated, that the most trifling blow on the abdomen may be followed by symptoms sufficiently serious and alarming, and require our utmost skill and attention.

In most cases, should symptoms of peritonitis supervene, we may safely resort to the free application of leeches to the abdomen, over the part chiefly in pain; and these should be followed by large and hot fomentations of moist flannels, or flannel-bags of bran or camomile wrung out of hot water, or large linseed-meal and bran poultices. Sometimes the relief to pain and the personal and local comfort afforded by leeches and subsequent warm applications, is most marked in these cases, and often highly satisfactory to the patient and beneficial in treatment. Opium, under the circumstances of peritonitis supervening, is the sheet-anchor of the vessel riding in a gale of wind. Opium should be given freely, fully, and frequently. The index to its limit is the effect on the system. We should only allow it to be diminished or withdrawn when narcotism is indicated by the manner of the patient, or the effect observed on the irides, or an abatement marked in the severity of the local symptoms, for the relief of which it was ordered. Calomel, in our opinion, should also be combined with opium, in these peritoneal affections, though only in small doses often repeated. It should be withheld on the first evidence of its specific action on the mouth and tongue.

Purgation should be avoided as a provocative of inflammation in these, as in all inflammatory affections within the region of the abdomen resulting from injury. If rest be desirable to the broken limb, equally is quiescence necessary to the recovery of the patient with lacerated tissues within the cavity of the abdomen; and any purgative may be looked upon as mischievous in such injuries. To allow an inflamed eye or any injured organ to recover, we advocate rest, that nature may exercise her share, not a small one, in the restoration of each to health. It is the well-judging surgeon who, taking a hint from nature's teaching, leaves to rest and quietude that which by active treatment might be seriously injured. And yet purgatives of an irritating character are sometimes recklessly advocated in the early stages of such accidents; a treatment which cannot be too strongly condemned, and a practice which only appears adapted to accelerate a fatal termination. If constipation supervenes, the mercurial treatment should be steadily persevered in, short of salivation to the slightest degree; and trust should be placed in the natural action of the intestine, subsequent to the reduction of inflammation, rather than in any efforts made to hasten the action by other measures, with an expectation that purgatives can lessen the local mischief.

Rupture of the diaphragm is not a very common injury, and when it does occur is usually the result of much external violence. In such a case, there is generally found to be some serious visceral mischief associated with the laceration of the muscle. But a rupture of the diaphragm may take place without lesion of the adjacent viscera; and in such an instance hæmorrhage will in all probability be small in quantity.

A wound of the diaphragm may be readily produced; the muscle has been often transfixed by a knife, or bayonet, or other sharp-pointed weapon thrust into the lower portion of the thorax, or through the upper portion of the abdominal wall. A wound of this muscle produced by a penetrating instrument will, most probably, be complicated with wounds of some of the adjacent viscera; and in such a case hæmorrhage will generally be rather severe.

A rupture or wound of the diaphragm, if not complicated with visceral injury, and if not considerable in extent, is by no means necessarily, of itself, immediately or ultimately fatal. Even with a large laceration of this muscle a person may live for some months. The second case recorded at page 650 is a well-marked instance of a severe laceration of the diaphragm: in this case the patient survived eleven weeks, although the laceration was complicated with rupture of the spleen.

There is no limitation to the part of the diaphragm which may be the seat of a *wound*, but in the greater number of cases of *laceration* it has been observed that the injury has been confined to the left side. Devergie has confirmed this observation, which is supported by the case on p. 650, and by the following instances:

Thomas A., aged twenty, was admitted into St. Mary's Hospital, 'suffering from pneumo-thorax and diaphragmatic hernia,' of which he died about thirty-two hours after admission. 'The opening in the diaphragm was in the left portion of the tendon, near its posterior part, and was large enough to admit the hand.'*

E. L., aged forty, was admitted into Guy's Hospital, having fallen from a great height on to the deck of a vessel. He died about three months after the accident. An opening was discovered in the diaphragm a little to the left of the œsophageal opening, about two and a half inches in extent.†

The symptoms of laceration of the diaphragm, we may conclude, will be generally of an obscure character; and it will very much depend upon the manner in which the accident occurred, whether sufficient symptoms will be referred directly to the seat of injury to enable the surgeon to arrive at a correct diagnosis. If the rupture be the result of a fall from a height, or of a heavy weight having passed over the abdomen, there will be so much general bruising, or visceral laceration, that any symptoms of rupture of the diaphragm will escape detection in the more severe and urgent condition of the patient. But the muscle may be ruptured by sudden spasm or action caused by a slight fall or slip. The patient would, under such circumstances, be cognisant of an instantaneous snap or darting sensation in the part, followed by intense pain. There would also be more or less difficulty in walking; inability to use much muscular power; and most probably some disturbance or difficulty in the respiratory movements.

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* *British Medical Journal*, 1858, p. 922.

† Poland's *Prize-Essay*, p. 330; also *Guy's Hospital Reports*, 1838, p. 366.

Thomas A. (the case already quoted) 'slipped while walking in his own house; and in trying to save himself from falling, gave himself a severe twist, when he felt something snap at the lower ribs on the left side, followed by great pain, to such an extent that he could hardly breathe for some minutes.'

A laceration or wound of the diaphragm *per se* is not necessarily fatal. But the aperture in the muscular septum is generally productive, sooner or later, of serious results. These serious consequences arise from the escape of some of the contents ofthe abdomen, through the laceration, into the cavity of the thorax; such a protrusion constituting that variety of hernia termed phrenic or diaphragmatic. 'A uniform effect of these ruptures when extensive,' writes Dr. Alfred Taylor, 'is a protrusion of the stomach into the chest, with sometimes a rupture of the coats of that organ, and extravasation of its contents.'* But portions of the small intestine, transverse colon, omentum, and spleen have been found in the cavity of the pleura subsequent to an extensive laceration of the muscle.

The symptoms of such protrusion into the cavity of either pleura would be generally well marked. The side of the chest implicated will be somewhat prominent, and the heart will, to a corresponding extent, be pushed over in the opposite direction. On percussion the sounds may vary. If the protrusion be stomach or intestine distended with air, the resonance will be most evident; but should solid viscera have passed through the laceration, the sounds will, to a corresponding extent, be dull. No respiratory sounds will be heard, under either condition, over the part in which lie the escaped viscera. Constant vomiting will also be generally present. With the escape of portions of the viscera into the cavity of the chest, obstruction to the passage of their contents usually occurs, and the patient's life is soon sacrificed. Or death may follow an attack of pleuritis either set up immediately by the rupture, or subsequently produced by the irritation of the foreign viscera in the cavity of the thorax.

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* *Medical Jurisprudence*, p. 392.

We are silent on the subject of treatment in this accident. As long as the opening in the diaphragm exists, there is the prospect of protrusion of viscera through it, and consequent obstruction. We cannot hope to close the aperture by any measures which science or mechanical surgery would justify; and therefore, could we most accurately detect the existence of a protrusion of viscera through the aperture, it were vain to attempt its reduction with any prospect of benefit to the patient or credit to ourselves.

Contusion of the parietes of the abdomen, complicated with rupture of viscera, is a subject replete with interest, and an injury more formidable in its character, and more fatal in its results, than most of those alluded to in this essay.

In their respective order, we must consider individually rupture of the food-tube and its accessories: viz. (1) the stomach and intestines, (2) the liver and the spleen.

As the result of accidental violence, rupture of the *stomach* in a state of health is a very rare occurrence. In its results, as a rule, it may be considered as surely fatal. Rupture or rather perforation of the stomach, the result of ulcer, is not an uncommon lesion; but is one rapidly fatal, and consequent on a long-standing and troublesome affection. Such an occurrence is characterised by sudden, sometimes excessive, pain, great depression and intense anxiety, rapid pulse, and every indication of immediately approaching death. A few hours suffice to terminate the sufferings of the unfortunate victim of this disease. It would be useless, were it our province, to offer any remarks on the treatment of such a case.

The blow or compression which would in a state of repletion be sufficient to produce a large rent in the stomach, would occasion but a very small opening if little food were contained in it; but however small in quantity this might be, the escape of the smallest portion into the peritoneal sac would be sufficient to originate violent inflammation, and that of a rapidly fatal character.

Under any circumstances, can we entertain a hope that rupture of the stomach may not prove rapidly fatal? It is just possible. If the laceration of the coats were confined to those portions which are attached to the omentum, above or below, extravasation of the contents might be limited in quantity, and confined to parts external to the cavity of the peritonæum;

though such a condition would probably be but a temporary stay to future mischief; for the extravasation would sooner or later terminate in suppuration, and the secondary mischief set up prove equally fatal, as a rule, as when it follows at once upon the escape of the stomach-contents into the cavity of the peritonæum.

It is probable that the following case may bear the above explanation. A woman received an injury on the abdomen, followed by an indolent swelling over the left part of the epigastrium,—which swelling, suppurating, and ulcerating externally, formed a fistulous communication with the cavity of the stomach. The woman lived some months after the formation of the fistula. On the examination after death, the opening in the stomach was found towards the pyloric extremity, and was intimately adherent to the abdominal parietes.*

In the first number of the *London Medical Review,* July 1860, is recorded a case of rupture of the stomach, in a man aged twenty-four, who fell from a ladder on some iron railings. He died about eight hours after the accident. When admitted into the Middlesex Hospital, under the care of Mr. Moore, the patient was perfectly sensible, but in a state of great prostration—pulse very small and feeble. Brandy was administered. This he took with great reluctance, and at his earnest request it was not persisted in. He stated that it increased his sufferings.

Post-mortem examination.—'The cavity of the peritonæum contained about twenty-six ounces of fluid, resembling coffee-grounds. On the anterior aspect of the stomach, just below and to the left of the pylorus, was an abrasion of the peritoneal coat two inches in length. Immediately beneath the pylorus, the anterior wall of the stomach was completely ruptured, in a horizontal direction, for the space of three inches. The mucous membrane of the stomach, just above and just below the rupture, presented two clean cuts, exposing the submucous tissue, which was intensely injected. The upper of these cuts measured three inches, the lower one, an inch and a half.' Most of the ribs on the left side were fractured, and there was rupture of the spleen. 'There was a superficial abrasion of the liver, an inch long, on its inferior surface. Close to the internal abdominal ring, on the right side, was a rupture of the peritonæum, large enough to admit the thumb. There were also numerous abrasions of the peritoneal coat of the transverse colon.'

Perforation of the *intestine,* that is, rupture of the intestinal coats, the result of external violence, without any external wound, is by far the most frequently formidable injury of the abdominal viscera with which the surgeon has to contend in practice. From the commencement of the duodenum to the termination of the sigmoid flexure of the colon, in any part of the whole length of the intestine, rupture of the entire wall does constantly occur from violent, sudden, or passive forces applied to the front or sides of the abdomen. We propose to consider the various forces which produce such accidents, and the various situations in which the injury may occur.

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* Richerand, *Physiol.* tom. i. p. 282.

Rupture of intestine is a very common result of a kick from a horse; in very many cases admitted into St. George's Hospital with rupture of the bowel, the injury was attributable to this cause. In such cases, the aperture in the bowel is generally small; whereas more extensive lacerations are found when the injury has been caused by heavy weights passing over the body. In the latter instances, the intestine may almost be severed transversely. Every variety, from a small pin-hole perforation to an entire transverse division of the walls of intestine, may occur from a variety of forces acting on the abdominal walls; but into these points it is not necessary to enter more minutely. It may fairly be asked, whether a rupture of the intestine is to be considered a fatal accident? It can, we fear, rarely happen that recovery should take place, if the lesion be sufficient to permit the escape of fæcal matter into the peritoneal cavity, and the rupture be not accompanied by an external wound. The effects of such a lesion are so formidable, that we may certainly, as a rule, pronounce all such cases to be utterly beyond the boundaries of relief and recovery.

A man was admitted into St. George's Hospital in December 1841, having been rolled upon by a horse that fell with him. The patient complained of severe pain across the abdomen: countenance very pale; pulse very weak; not much tenderness on pressure; vomiting soon commenced after admission. The following day all the symptoms were aggravated; the pulse became very quick and small; countenance very anxious. He died thirty-four hours after admission. There were general adhesions of the peritonæum to the great omentum, and also of the convolutions of intestine to each other; the lymph being of dark grumous colour. The cavity of the peritonæum contained a large quantity of bloody fluid, quite free from fæcal taint. About the middle third of the jejunum, the bowel was formed into a kind of loop from adhesion to the transverse colon, and presented a very dark and congested condition; on separating the adhesions, a small rupture of the jejunum was seen; escape of the contents of the bowel had been prevented by firm adhesions, and also by a large coagulum formed in the immediate situation of, and fairly surrounding the rupture. Some portions of the intestine presented a dark appearance, as if bruised.

Such a case as the above marks the possibility of rupture of intestine without escape of fæcal matter. This patient probably died as much from the effects of inflammation, set up by the bruised intestine, as from the effects of the rupture. The post-mortem appearances in this instance are a fair index of the pathological conditions generally found after similar injuries.

The immediate effects of such a lesion as rupture of bowel from external violence are most characteristic. The pain following the blow is rapidly merged into that which is often excessive, and is apparently the result of the escape of fæculent fluid into the peritoneal sac. Pain is much increased by pressure, and sometimes to such an extent that the patient cannot bear the weight of the bed-clothes. The anterior abdominal muscles become rigid and unyielding to the touch; tense, hard, and resistant to any examination by the hand; and almost convey the sensation of a board, rather than that of animal tissue, laid over the surface of the bowels. If the abdomen be uncovered, and the patient requested to draw a long breath, the action of respiration will be observed confined to the thoracic muscles: those of the abdominal wall will be still, fixed, and unmoved. The countenance rapidly assumes the most anxious and restless aspect; vomiting sets in early, and is more or less constant and distressing to the end; the fluid vomited being at first the remains of the last undigested meal, and then porraceous, and latterly dark-coloured, slightly tainted by fæculent smell. The tongue varies in appearance, but generally is coated and dry, and red at its edges; great thirst is often a marked symptom. A symptom spoken of as a sure indication of ruptured bowel, is early and excessive collapse; but collapse, though generally present to a great extent, will sometimes be wanting to such a degree, that if, as a symptom, it be much depended on, an incorrect conclusion might be arrived at respecting the extent of the injury.

The coachman of my friend and colleague Dr. Fuller was kicked on the abdomen by a horse, early in the morning. The man experienced great pain immediately after the accident, but was able to walk some little distance from the stable to his lodgings, and then upstairs to his bedroom, without any indication of collapse. When I saw him with Dr. Fuller, about an hour after the accident, there was no collapse, and the pulse gave very little indication of serious mischief; but the pain, the tense state of the abdominal muscles, the anxiety of countenance, and the vomiting then present, pretty surely indicated rupture of the gut. The post-mortem examination displayed a lacerated opening in the small intestine.

It may appear superfluous to speak of treatment, when we start with the conviction that rupture of bowel is necessarily fatal. But in these serious injuries, if treatment is to be of avail, it certainly appears absolutely necessary that all our efforts should be directed to the maintenance of rest in the injured part. It will be found that vomiting and costiveness are the invariable accompanying conditions of ruptured intestine. Nature's indication, as well as nature's effort, appear to be, to avoid all disturbance, and preserve strict rest of the injured part, by emptying the tube above, and arresting its action below; and the lesson she teaches us we should be ready to appreciate and enforce. Opium administered internally from the first, is one great indication, marked by her teaching. We learn the advantages of opium administered in instances of bruised or inflamed intestine reduced after strangulated hernia; equally important, if not more so, is the action of this drug in cases of ruptured bowel. The dose is only to be suspended when narcotic effects are evident, but otherwise should be repeated and increased until some beneficial or specific action is observed. Leeches to the abdomen, fomentations, sinapism, and turpentine on flannel, should be applied much in the order stated; and the leeches repeated, if requisite to relieve pain, &c. In such cases depletion cannot be had recourse to often, or carried very far with benefit. The pulse soon begins to fail. It must ever be borne in mind with respect to treatment, that the inflammatory action is the result of local extravasation, and not of idiopathic or constitutional causes, and therefore less under the influence of general measures. It is a question how far mercury should be administered in these injuries. I believe it to be occasionally a beneficial, and therefore justifiable, therapeutic agent, but only in combination with opium; and with opium it should be administered in the early stages of the symptoms, in small and oft-repeated doses. One grain of each drug may be given every three or four hours. The repeated doses of opium will often be borne for many hours, and the patient in no way injuriously affected by it.

A few hours to three or four days will be the extremes of time that a patient may survive after the occurrence of a rupture of the bowel. Upon examination after death, marked evidences of the escape of the contents will be present: general peritonitis, the edges of the convolutions being glued together; discoloured and purulent fluid confined between the folds of the intestine, and especially in the lower portion of the peritoneal cavity. According to the size of the rupture, so in a great measure will be the amount of effusion, as also the rapidity of the termination of the case; for the symptoms will be more acute, and the progress more rapid, the larger the escape of fæculent fluid. The wound in the intestine will often be hidden by adhesions, and care is sometimes required to ascertain its situation. It will probably have early become adherent to the adjacent surface of bowel, or omentum, or any neighbouring viscus, and, as a consequence, before the period of death escape of the contents of the gut will have ceased. The edges of the wound are always found everted, and the mucous coat projecting, plugging up the aperture when not of a very considerable size.

In an injury such as we have now considered, what prospect has a patient of recovery?

It would be mere conjecture to suppose a case of recovery probable after escape of fæcal fluid into the peritoneal sac. It only appears possible that a patient should even survive for a time, *i.e.* beyond a few days, if the rupture were situated at the attached margin of the bowel, and the escaped fæculent fluid were confined between the layers of the mesentery. In such an exceptional case we must expect subsequent serious mischief. Abscess and chronic peritonitis, and more or less adhesion of the surfaces of the intestines and viscera, would be the chief features of the case: matter might approach the surface, and be detected in time for evacuation, before discharging into the peritoneal cavity. Such a case is not unfrequently met with after convalescence from fever, or from ulceration and perforation of intestine from other causes. Such a case would be long in recovering, and would call forth all the attention and skill that the experienced practitioner could bestow upon it. An early exit for the pus would be most important, and great care should be taken to prevent burrowing sinuses, and confinement of matter.

Lacerations of the substance of the *liver* will be frequently met with in post-mortem examinations of persons whose deaths have been occasioned by injuries to the abdomen; but though such lacerations are not uncommon results of accidents, the termination need not necessarily be fatal.

If the laceration be not extensive—if it be limited to the surface of the liver, merely a slight superficial crack—the patient may recover without much suffering, and without any particularly marked indication of the existence of the injury.

If the laceration be at all extensive or deep, the patient soon dies from the effects of hæmorrhage into the peritoneal cavity. Post-mortem examinations bring before us every condition of rupture, from the slightest rent running through the peritoneal covering, and barely tearing more than the most superficial surface of the liver, to the most complete smashing up of the organ. Only in the slighter injuries can we anticipate a favourable result. Death rapidly steps in, and appropriates the more serious.

A man, aged thirty-three, was admitted into St. George's Hospital, November 25, 1847, under the care of Mr. Cutler. The patient was blanched, and in a cold sweat. He had been shortly before kicked on the epigastrium by a horse. The man was in great pain, and excessively faint, and became rapidly more exhausted. He died an hour and a half after admission. There were marks of recent ecchymosis over the epigastrium, and in the substance of the muscles, especially on the left side. The cavity of the peritonæum contained much fluid blood. There was a very extensive laceration of the liver, nearly separating it into two portions, these being held together by nerves, vessels, and some shreds of bruised liver-tissue. There were also some lacerated spots on the posterior surface of the left lobe. The other viscera were healthy.

Rupture of the liver may occur without rupture of the peritoneal coat, and without hæmorrhage into the peritoneal cavity. A man, aged twenty-five, was admitted into St. George's Hospital, May 26, 1847. He was pale, cold, and gasping for breath. He died in two hours. The wheel of a heavily-laden cart had passed over him. The peritonæum covering the upper surface of the liver appeared slightly bruised. On cutting into the upper part of the right lobe, considerable laceration of the substance was found, though the peritonæum was entire.

In this instance there was also extensive laceration of one lung, and fracture of several ribs; but, irrespective of such complications, the injury to the liver might fairly be considered as one favourable to recovery;—an instance of laceration of the liver unattended by hæmorrhage into the peritoneal cavity.

We cannot mention any definite symptom by which, during life, a rupture of the liver may be unmistakably detected. If the rupture be slight, there is but little beyond the usual symptoms attendant upon an injury of the abdomen, not of a severe character. Greater tenderness may be experienced over the region of the liver than elsewhere; but such a symptom cannot be assumed to be positively demonstrative of laceration; for, on the one hand, the tenderness may exist after a direct blow without rupture, or, on the other hand, the liver may be lacerated from violent concussion of the organ, and there be no marked or defined local pain.

When the laceration is extensive, it may be suspected more surely than when slight, from the rapid collapse of the patient;

loss of pulse, extreme faintness, pallor, and great distension of the abdomen—all indicative of excessive internal hæmorrhage.

Injuries of the abdomen productive of laceration of the liver, and attended by such hæmorrhage, are perhaps the most rapidly fatal of all; and patients will expire in periods shorter or longer, proportionate to the amount of the bleeding.

It would be useless to talk of treatment in such cases. Death steps in and removes the patient from suffering, often ere the question of restorative treatment can barely be entertained. But in minor lacerations every precaution requisite in the treatment of other injuries of the abdomen must be strictly observed. Absolute rest is one most essential condition to be insisted on. *The patient should not even be allowed to raise himself or be raised in bed*, if it be suspected that much blood has escaped into the cavity of the peritonæum or elsewhere. For under such circumstances, though the patient may appear to be going on well, death may occur upon the slightest exertion. If pain supervene, and the pulse indicate increased action, leeches may be applied with caution. But opium should be administered, alone, to quiet the nervous system, or combined with calomel in small doses, should peritonitis be evidently commencing. Fomentations, or large warm poultices applied over the whole of the abdomen, frequently procure considerable relief in pain, and afford great comfort to the patient under such circumstances. The treatment must, however, be guided by symptoms, and no very general law can be laid down as to its adoption.

Pain is frequently felt over the region of the injured part for some time subsequent to recovery: such pain indicates the necessity of care on the part of the patient; for secondary inflammation may be set up by any prolonged or reckless indulgence in exercise or violent exertion. *It is always impossible to estimate the amount of injury in the most favourable cases, or to calculate the amount of blood extravasated.* With judicious treatment in the early stages of the injury, the rupture of the liver may have united, and the effused blood may have commenced to disappear, but adhesions of the peritoneal surfaces about the injury probably exist to some extent; if by too active movements on the part of the patient these adhesions become disturbed or destroyed, all previous benefit may be entirely lost, and a fatal termination be the result.

The following case indicates the extreme importance of strictly maintaining the recumbent posture after severe collapse.

A man, aged forty, was admitted into St. George's Hospital in May 1845, under the care of Mr. Cutler. The patient was in a state of collapse, and complained of intense pain over the abdomen, which was considerably distended; some of the ribs on the right side were fractured. The pain gradually subsided, though the patient remained very exsanguine. He appeared to be gaining some strength, when he died suddenly, three days after the accident, on attempting to raise himself up to get upon the bed-pan. The cavity of the peritonæum contained a large quantity of blood. The convolutions of intestines were glued together by the fibrin of the extravasated blood, which had partially lost its colour, and formed slender adhesions. There was an extensive rupture of the liver. The ruptured parts were well adapted to each other, and pretty firmly united by the fibrin of the extravasated blood.

That a rupture of the liver may unite, and that a patient need not die from the effects of such an injury, there can be no doubt: the following case is an illustration.

A man, aged thirty-eight, was admitted into St. George's Hospital, under the care of Mr. Cæsar Hawkins. The patient had fallen from a hayrick, and struck his back against a log of wood. There was complete loss of voluntary motion and sensation in the parts below the nipples. There was considerable collapse, which continued for several hours. The urine drawn off contained a large proportion of blood. Sloughs formed upon the back, &c., and death occurred exactly three weeks after the accident. The body of the seventh cervical vertebra was broken into fragments, and the spinal cord corresponding to this vertebra was softened and diffluent. The cavity of the peritonæum contained a little bloody serum. An extensive rupture was found on the upper surface of the right lobe of the liver; this rupture, which measured five inches in length, was perfectly united, with the exception of some few points, where the peritoneal coat still remained broken; but no lymph was found on the serous membrane, which retained its polished surface. *The rupture did not extend very deeply into the organ.*[*]

Such a rupture as the above, occurring without other mischief to the body, may reasonably be considered as by no means fatal in its character, nor in this instance can the injury to the liver be looked upon as at all implicated in the cause of death.

In conclusion, from the results of the cases quoted, and for the reasons adduced, we may fairly state that the treatment of the *convalescent* is a matter of as great importance as that of the patient in the early days of an injury suspected to be laceration of the liver.

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[*] 'Cases of Ruptured Liver,' by Mr. Athol Johnson, *Med.-Chir. Trans.* vol. xxxiv.

Rupture of the *gall-bladder*, or of the common duct, may occur without rupture of the liver. The symptoms are generally marked—considerable pain in the region of the injury, excessive collapse, and great anxiety. Death is generally rapid; and post-mortem examinations have detected the escape of the bile into the cavity of the peritonæum.

Mr. Poland relates the following case. 'A boy received a blow on the abdomen, followed by great pain and speedy death. There was found extravasation of bile, and rupture of the ductus communis choledochus, with lymph thrown out in the neighbourhood.' *

Dr. Fergus has recorded an interesting case of rupture of the gall-bladder, in the 31st volume of the *Medico-Chirurgical Transactions.* A boy, aged seventeen, fell off the shaft of a cart, the wheel of which passed over the abdomen, just below the false ribs. The boy complained of pain in the abdomen, but not of a severe character; the amount of shock was trifling. In the night following the accident, severe pain commenced in the abdomen—the countenance became anxious and the pulse small and rapid. These symptoms were actively treated; and he improved so much that on the fifth day after the receipt of the injury he was considered convalescent, and was allowed to get up. Two days subsequently, he was so far recovered, that the question of his quitting the hospital was entertained, when about noon he was suddenly seized with extreme pain and a sense of tightness in the abdomen: in an hour the pain had extended all over the abdomen, and was increased by pressure; the countenance was full of anxiety, and the pulse small and rapid; the symptoms present were those of acute peritonitis, from effusion of foreign matter into the cavity of the abdomen. Notwithstanding the most judicious treatment, the symptoms increased in severity, and the patient died on the ninth day after the first receipt of injury.

On opening the cavity of the peritonæum, an immense gush took place of a dark liquor, having precisely the colour and odour of bile. The intestines were roughened from the effects of peritonitis, and shreds of lymph were floating in the dark fluid. 'The liver was lacerated in the direction taken by the broad ligament, quite through its substance, and to a depth from the thin edge of two inches and a half; another laceration extended about two-thirds of the length of the convex surface in a transverse direction. The omentum was found rolled up in a mass underneath the liver, and slightly adherent to it, of a dusky dark colour, and gave way under the least pressure. The neighbouring portion of the transverse colon was of the same colour, and nearly as fragile. The gall-bladder was ruptured above, near the junction of the hepatic with the cystic duct, at a spot in immediate relation and in contact with the mass of omentum above described; the gall-bladder was quite empty and contracted.

The question arising from the history of this case is, whether the secondary and sudden attack of inflammation might not have been dependent on the extravasation of bile, just previous to the attack of pain—this extravasation being the result of some of the adhesions between the omentum and the gall-bladder becoming broken up by accidental causes. The case points out, in its progress and by its result, the very great importance of enforcing rest and quietude in all injuries of the abdomen, such as this boy had suffered. We may consider, that, after an injury to the abdomen, a patient is not safe under the period of a fortnight, even if he be entirely free from all symptoms.

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* *Prize-Essay*, by Alfred Poland.

The *spleen* is frequently ruptured in injuries of the abdomen. Such lacerations generally occasion considerable internal hæmorrhage. The symptoms attendant on any rupture of the spleen will barely justify an opinion being hazarded whether the laceration be in the spleen or in the liver. The symptoms do not vary much in either injury; the only points which can in any degree guide our diagnosis are, the nature of the blow and the situation of the injury. If the laceration of the spleen be more than very superficial, hæmorrhage will probably be more considerable than it would be in a similar extent of laceration of the liver, and death will rapidly follow.

A boy about nine years old was pushed into a gravel pit by a companion, and in falling struck his left side against the edge of a barrow. This occurred after his dinner and while on his way back to school for the afternoon. He felt much pain at the time, but not liking to complain managed to walk into the schoolroom. He then soon became very faint, and appeared so ill that he was at once sent home, but a short distance off; and was immediately seen by Mr. Halford of Hammersmith. He found the little patient very much collapsed and in much pain. In consultation with the author the boy was seen the following day. The abdomen was distended, muscles unyielding, and all the general indications of severe visceral laceration with peritonitis commencing.

These symptoms increased in severity, and the boy died a few days after. The spleen was found nearly separated into three portions, and much smashed; a large quantity of blood was extravasated in the abdominal cavity, and mixed with recently effused lymph and purulent fluid.

Though rupture of the spleen need not prove *immediately* fatal, secondary mischief may supervene and *ultimately* produce death.

A man, aged twenty-four, was admitted into St. George's Hospital under the care of Mr. Cæsar Hawkins, August 29, 1845, having fallen from a scaffold the height of about twenty feet. On admission, the patient did not appear to suffer more than from a serious shake; but about three hours afterwards he became collapsed almost like death, and was scarcely conscious for a short time. He gradually recovered from this condition, and then complained of pain in the left lumbar region. During the following nine days he had repeated fainting-fits; but these disappeared subsequently, and he appeared to be gaining strength slowly. In October, he was sufficiently recovered to sit up, and even walked one day from his bed to the fire-place in the accident-ward, a distance of about twenty feet. Subsequent to this exertion, he was again attacked with faintings, increased pain, cough, &c., and he died November 15, about eleven weeks after the accident.

The cavity of the left pleura was divided by adhesions: the upper half contained serum and flakes of lymph; the lower half was filled with sero-purulent fluid and lymph. The pleura corresponding to the latter surface was covered with a thick layer of lymph. The surface of the left lung, corresponding to the diaphragm, was adherent to the latter. A large foul abscess occupied the lower portion of this lung: and this abscess communicated with a large cavity containing pus, between the lung and the diaphragm. Corresponding to the lower surface of this cavity was a ragged opening in the diaphragm, about an inch in length, through which the abscess in the pleural cavity and lung communicated with one in the cavity of the abdomen, behind and to the left of the stomach.

The surface of the peritonæum was throughout of a black colour, as if washed over with ink. There were numerous adhesions of the peritonæum. The posterior surface of the left extremity of the stomach was fastened down by adhesions, in separating which an abscess containing half a pint of pus was found; the walls of this abscess were formed by the stomach and transverse colon, the diaphragm, and the upper surface of the left kidney. The spleen was found ruptured into two portions: one, the upper portion, being surrounded by pus, and, as it were, in the abscess; while the other, the lower portion, was situated in front of the abscess. The inferior surface of the diaphragm corresponding to the abscess was lacerated from the median line to the extent of six inches to the left side.

Rupture of the *kidney* is a lesion often met with in post-mortem examinations of individuals whose deaths have been occasioned by violence. This lesion may, however, occur, independent of injury to any other viscus; and the termination may be rapidly fatal. A bruise of the kidney may occur without rupture of the surface; and subsequent inflammation, the result of the bruise, produce abscess, and other more serious mischief.

A gentleman was bruised over the left loin by a fall in hunting, and experienced severe pain in the back on arriving home. He was very judiciously treated for some weeks after the accident, and came under the notice of the author some months subsequently. The bladder was now very irritable; and highly offensive urine, mixed with pus, was constantly passed. There was every evidence of abscess of the kidney: the quantity of pus was sometimes very considerable. The health became gradually deteriorated, and death occurred about two years subsequent to the accident.

The left kidney was entirely destroyed; and in its situation was found a large irregular abscess, with its walls adherent to the surrounding soft tissues, and its cavity continuous with the ureter.

Without much more external evidence of bruise than in the previous case, very extensive laceration of the kidney may result from a blow over the lumbar region.

A boy was struck, over and rather in front of the right lumbar region, by the handle of a truck, in consequence of the truck coming in collision with a wagon. From the violence of the blow, the boy was forced against a post of a gateway. He immediately fell, and though able to rise and walk a few steps, he again fell, and was then carried to Guy's Hospital. He was in a state of extreme collapse, with some pain in the abdomen. He died within a hour and a half of the accident.

Externally there was slight ecchymosis over the extremities of the seventh and eighth ribs on the right, and the last two ribs on the left side. The cavity of the peritonæum contained a large quantity of coagulated and fluid blood. All that portion of the left kidney above the entrance of its vessels was torn from the lower portion, and was separated from the natural surrounding attachments. The lower portion was not disturbed in its position. There was some ecchymosis on the surface of the liver, opposite to that on the chest.*

In proportion to the severity of the injury must we anticipate different features in the symptoms which accompany laceration of the kidney. Generally there will be excessive collapse, attended by early vomiting; pain referred to the course of the ureter, as well as to the lumbar region; retraction of the testicle and frequently great pain referred to the testicle itself and to the lower part of the abdomen; and numbness of the upper part of the thigh. All these symptoms will probably increase in severity, should the patient survive, and infiltration of urine occur. The urine drawn off will be high-coloured and scanty, and will generally be much tinged with blood, often containing a very large proportion of blood. There will frequently be observed, passed through the catheter, long, thin coagula, the casts of the ureter, taken by the blood, as it coagulates in its passage to the bladder.

Should the rupture of the kidney be confined to the anterior surface, and any escape of urine occur through the lacerated part, acute peritonitis will rapidly follow. If the rupture be confined to the posterior surface, and urine be extravasated into the sub-serous cellular tissue, though the symptoms may, in the first instance, be less indicative of peritonitis than in the former condition, suppurative inflammation will soon be marked by its characteristic symptoms; and rigors, high fever, typhoid tongue, and œdema of the parts in the neighbourhood of the injured organ will telegraph the mischief immediately threatening life.

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* *Prize-Essay,* by Mr. Poland.

There is no question, however, that a rupture of the kidney need not be necessarily fatal. The following case is a fair illustration of recovery from such an accident.

A man, aged thirty-seven, in June 1858, was taken to St. George's Hospital, having been kicked by a horse. The patient was very faint on admission, and became so much worse after a very short time, that it was supposed he was dying. However, he rallied by degrees. After a short period, a swelling was observed in the region of the liver. The belly commenced to swell, and continued to do so for some time. The urine at first passed was mixed with blood; on the day following the injury, there was less appearance of blood; and, subsequently, the urine was free from blood. He gradually recovered under careful treatment, so as to leave the hospital July 20, about six weeks after the accident, in a pretty good state of health and comfort. On Dec. 14, 1859, he was readmitted, suffering severely from anasarca, oppressed breathing, and urine loaded with albumen. He died Dec. 22.

There were numerous adhesions uniting the right lobe of the liver to the diaphragm, but there were no absolute marks of recent rupture. Both kidneys were small, granular, and full of cysts. The cellular tissue around the right kidney was much consolidated. A large clot of blood occupied the pelvis and the interior of this kidney, and communicated also with the exterior of the organ, where a considerable quantity of coagulum lay in the sub-peritoneal substance around the gland. The line of rupture of the kidney could be faintly traced through the substance of the gland. The blood was solid, and only partly decolorised. The ureter was completely impervious with coagula.*

We may conclude that recovery is a result almost entirely dependent on the extent of rupture; if the latter be slight, recovery may readily occur—if extensive, treatment is hopeless and death certain.

A man was admitted into St. George's Hospital, under the care of the author, with severe pain in the right side of the abdomen and loins; the result of a fall. The urine drawn off was loaded with blood. There was much tenderness on pressure, and some tumefaction with resistance of the abdominal muscles on the side affected. Symptoms of acute peritonitis supervened, and the patient died in a few days.

A post-mortem examination disclosed a kidney nearly divided in two, on the right side, with extensive extravasation of blood around the damaged viscus, but confined to the sub-peritoneal cellular tissue, and mixed with fœtid purulent fluid, apparently the result of urine extravasated, and escaping from the lacerated pelvis of the kidney. There was no escape of blood or urine into the cavity of the peritonæum.

Absolute rest is the first consideration in treatment. Should vomiting or pain set in, opium should be administered freely, care being taken to relieve the bowels moderately. The urine should be drawn off, in order to ascertain whether blood be contained in the bladder; and should this be the case, the use of the catheter should be had recourse to daily, until the urine becomes clear. Supposing the mischief to have been confined to the posterior surface of the kidney, and we have reason to suspect extravasation of urine through the wound, we must be prepared for suppuration. Frequent and careful examinations should be made, in order that an exit may be secured for the matter, as soon as its existence is suspected; we would strongly urge the advantage of a premature opening, in anticipation of the formation of matter, rather than that any delay should occur in giving it vent, when once established. Suppuration in the lumbar region spreads rapidly, and produces intense constitutional irritation, and will prove in most instances rapidly fatal. But should matter extend downwards and forwards, free incisions early made afford the best prospect of recovery to the patient.

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* *Path. Soc. Trans.* vol. xi. p. 140.

In the 27th volume of the *Medico-Chirurgical Transactions*, Mr. Stanley has reported two cases of ruptured ureter. A boy, aged nine, had the lower part of his body squeezed between a wheel and the curb-stone. The result was severe contusion of the soft parts around the pelvis, and inability to walk, with great pain at the lower part of the abdomen. Much ecchymosis ensued and was followed by extensive suppuration in the subcutaneous tissues round the pelvis; and several ounces of matter were discharged through a puncture near the left sacro-iliac symphysis. By the end of the sixth week, recovery of the injured soft parts round the pelvis had considerably advanced, when attention was drawn to a fulness on the right side of the abdomen—a circumscribed oblong swelling, extending from the base of the chest to within a short distance of Poupart's ligament; anteriorly terminating abruptly at the linea alba, posteriorly extending into the lumbar region, but without a distinct boundary. Pressure produced no pain, but fluctuation could be recognised. The urine passed naturally, as it had done throughout, and the passage of the catheter proved that none was retained in the bladder. A small puncture was made in the swelling, and a little clear yellow fluid escaped. The fluid was situated immediately beneath the abdominal muscles. Three weeks subsequent to the first puncture, the swelling being more tense and pointed, a trocar introduced midway between the last rib and crista ilii drew off 51 ozs. of clear yellow fluid. Eleven days afterwards, 58 ozs. of clear yellow fluid were drawn off; sixteen days subsequently, 64 ozs.; nearly three months afterwards, 72 ozs. Three weeks after this, only 6 ozs. were removed. 'From this period the swelling was without increase or obvious diminution; it still extended from the linea alba into the right lumbar region.' At several subsequent periods Mr. Stanley saw the boy in good health, the abdominal swelling still distinct, but slowly diminishing. The fluid drawn off was slightly alkaline, highly albuminous, specific gravity 1008, depositing no precipitate, and destitute of phosphates and lithic acid. In some of the fluid taken away at the later operations, there were most unequivocal evidences of urea. '*The analysis of the fluid seemed to justify the conclusion that the fluid was urine.*'

The second case was that of a woman who was knocked down by, and pushed some way before, the wheel of a cart. She was much hurt in the right hypochondrium, where pressure gave considerable pain. In a few days the general distension and pain of the abdomen had subsided, but there remained a circumscribed swelling in the right hypochondrium. This swelling increased, and after some days a feeling of deep fluctuation was discovered. The fluid advancing nearer to the surface, and the constitutional symptoms indicating the occurrence of suppuration, the swelling was punctured with a small trocar, and between two and three pints of straw-coloured urinous-smelling fluid drawn off. The urine from the bladder had throughout passed freely and in full quantity. In ten days subsequent to the first puncture, a trocar was again passed in, and about six pints of fluid drawn off. Much relief was at first afforded, but subsequently the patient sank, and died in the tenth week after the accident.

'A large cyst was found on the right side of the abdomen, behind the peritonæum, extending upwards to the diaphragm and downwards to the pelvis. The boundaries of this cyst were formed by lymph and thickened cellular tissue; within it was a large quantity of fluid, presenting the characters of a mixture of pus and fœtid urine. A passage was found extending from the upper part of the cyst into the pelvis of the right kidney. The aperture in the pelvis of the kidney was large and irregular; the appearances were such as might be expected to result from laceration of the membranous structure composing the pelvis. The liver presented in its anterior surface the marks of a slight laceration of its tissue, which was in progress of healing.'

Mr. Stanley adds: 'It will, I presume, scarcely be doubted that the case first stated was an instance of lesion of the urinary apparatus, probably a slight laceration of the ureter; permitting the escape of urine slowly into the cellular tissue behind the peritonæum. Both cases illustrate the difficulties that may arise in the diagnosis of such injuries. They show, moreover, that the rupture of the ureter, or pelvis of the kidney, may present this remarkable feature, when contrasted with the consequences of a rupture of the bladder—that whilst in cases of the latter injury, symptoms immediately arise, directly pointing to the organ which has suffered, in cases of the former kind (the lesion of the ureter or pelvis of the kidney) no symptoms may immediately arise leading to a suspicion of injury to any part of the urinary apparatus.'

We have already alluded to the possibility of recovery after laceration of a kidney on its posterior surface. The cases recorded by Mr. Stanley tend to confirm this view; and they also indicate the advantages of an early exit being given to the contents of any abscess, or cyst, the result of extravasation of urine. Regarding this point of treatment, Mr. Stanley observes: 'It may, however, be a question whether the best proceeding would be gradually to withdraw the fluid by repeated punctures of the cyst, and thus to favour the collapse and adhesion of its sides, or whether the urinary cyst should be punctured at its lowest part, in the view of maintaining the aperture free for some time, that the fluid may drain from it.' Provided the fluid be at all purulent, the latter method of treatment would no doubt be most judicious.

WOUNDS.

1. *Wounds of the parietes without protrusion of viscera.*—We now enter upon that division of our subject which treats of wounds of the abdominal wall, occasioned by a variety of weapons or instruments, without injury to, or protrusion of the viscera. Wounds of the walls of the abdomen are very common, and occur from a great variety of sharp or pointed substances, intentionally or accidentally thrust against, or that suddenly come in contact with the surface of the belly.

Sharp or pointed instruments usually produce clean incised or small penetrating wounds. The larger wounds of the abdomen are the results of persons being caught on hooks, or impaled on iron spikes; falling on china, or through glass; being tossed by horned cattle, or lacerated by the teeth of carnivorous quadrupeds. The extent and character of such wounds will therefore vary in every possible degree, and will depend in as great a measure upon the amount of force by which the instrument of injury is propelled, at the time of the accident, as upon the shape of the instrument and the direction in which it enters the body.

Superficial incised wounds of the abdominal wall are not generally dangerous in their character, nor troublesome to manage, provided the viscera escape bruise or other injury at the time of the accident. Lacerated wounds, when superficial, may also be considered free from much danger. But deeper wounds, whether incised or lacerated, without injuring the peritonæum, are more serious; from the fact, that there is always a liability to suppuration, burrowing deep, and extending in various directions under the muscles and fasciæ. The principles laid down for the treatment of wounds in general must be applied to those of the abdominal wall. Hæmorrhage, if it exist, must be arrested. Care must be taken to clear the wound of any foreign substance accidentally lodged in it; such as glass, china, or portions of instruments broken off by the force of the blow which inflicted the injury. It has frequently occurred that large foreign masses have been overlooked, and allowed to remain buried, for many months, in the muscular wall of the abdomen, after an accidental gap made by some sharp cutting material.

A sailor was admitted into St. George's Hospital, complaining of pain over the right lumbar region; produced apparently by some solid substance lodged underneath the integuments. Mr. Babington cut down upon the mass, and extracted the shaft of an originally three-pronged steel fork, now minus a handle, and with only two prongs attached, one prong having been broken off some time previously.

Scrupulous attention having been paid to the condition of the wound, and it having been ascertained to be free of any foreign substance, the treatment should be very simple. The abdominal muscles are to be relaxed by position, especially if the edges of the wound have the least inclination to retract. As a rule, sutures will be found most advantageous and effective in approximating and retaining the edges in apposition. Metallic wire sutures appear to offer many advantages over silk, in such cases.

It must, however, be borne in mind that in wounds of any depth about the abdominal walls, especially in the thicker parts, or wherever the muscles overlap each other, it will be found difficult, if not impossible, to maintain perfect apposition of the whole surface of the cut. There is always in such wounds a tendency for fluid, serous or sanguineous, to accumulate between the surfaces at the deepest parts. The existence of such fluid may be followed, in a comparatively short time, by foul suppuration; which, if allowed to remain confined, would produce alarming constitutional disturbance.

A man, æt. 31, was admitted into St. George's Hospital, on May 22, 1839, with femoral aneurism on the left side. The external iliac artery was tied by Sir B. Brodie on May 30. On the evening of the day of the operation, there was much pain about the wound, and the parts were very sensitive to pressure. The tongue was already brown and dry. On the following morning, the pain was more diffuse, but less intense; the tongue still brown and dry. The left side of the abdomen was hard and tender to the touch. The next morning, June 1, the pulse was 136, and small; the tongue brown and dry; countenance anxious; pain only referred to the neighbourhood of the wound. The adhesions of the wound were now broken down by Sir B. Brodie, and *much sanious putrid fluid immediately escaped.* The same evening the patient felt relieved; and the tongue became rather more moist. Subsequently, he continued to improve, and although some time recovering, he was entirely restored to health, and left the hospital about seven weeks after the operation.

In the treatment of the various wounds of the abdominal wall, however produced, it is always necessary to bear in mind that the treatment should be somewhat modified by the locality of the mischief. For instance, in the epigastric region a wound is apt to gape more than when situated in another part, on account of its proximity to the ends of the ribs, which tend to keep the integuments in that region always somewhat on the stretch. It will, therefore, be uniformly requisite to have recourse to sutures to maintain perfect apposition of the cut surfaces. If, again, the muscles are cut or torn, on either side, transverse to the direction of their fibres, attention should be more especially directed to the position of the body, to relax those muscles. If the wound be in the iliac region, it may be more formidable in its real than in its apparent character; not so much from its extent, as from its depth and its direction, and from the risk of the iliac arteries, or their numerous branches, being punctured or bruised.

We have already stated that if hæmorrhage exists, it should be arrested. The treatment of hæmorrhage does not fall within the province of the present essay; but perhaps we shall be excused if we trespass out of our province on this one occasion, and speak an extra word or two of caution to the practitioner who may have to deal with hæmorrhage in a wound of the abdomen. If there be severe hæmorrhage, and the wound not sufficient to allow the bleeding mouth of the vessel to be seen, no hesitation need be felt regarding treatment. The wound should be enlarged—enlarged until the wounded vessel can be seen, *and can be secured.* We need not fear hæmorrhage so long as such a wound is open, and we can place a finger on the bleeding point. When the surgeon trusts to external pressure, and closes the wound without securing the wounded artery, then there is abundant cause for anxiety. If these principles be of importance in hæmorrhage of ordinary character, they are tenfold important when applied to the treatment of wounds in the region of the groin, or the neighbourhood of the crest of the ilium.

If hæmorrhage be present from a punctured wound, but not in sufficient quantity to indicate the necessity of enlarging the wound, for the purpose of securing the wounded vessel, the wound should not be closed, otherwise much extravasation may occur. To close such a wound under such circumstances is likely to entail extravasation among the deeper tissues, to be followed perhaps by much suppuration. It will be far more prudent to leave a punctured wound with merely some light application over it, such as wet lint, and thus permit oozing to continue unchecked, than attempt to interfere with such bleeding by pressure.

Punctured wounds of the abdominal region, as in all other parts of the body, partake of a more complex and dangerous character than the incised or lacerated varieties. It is frequently difficult, sometimes impossible, to ascertain the extent of the mischief, or foretell the evils about to occur in a punctured wound of the abdomen. Mr. Poland, writing on such wounds, justly observes that 'they are not unfrequently followed by inflammation, suppuration, erysipelas, prostration, and death.' Punctured wounds prove most troublesome when they extend below the fasciæ of the abdominal muscles, and give rise to suppuration. In such instances the mischief spreads rapidly in the deeper cellular tissue, and between the layers of muscles, unless early relief be afforded by freely extending the original wound. In instances of the above injury, if the external wound be kept closed, and much extravasation have occurred, the suppurative stage occasionally produces excessive constitutional disturbance, and may even prove rapidly fatal.

We would lay it down as a rule, firstly, that *in punctured wounds* of the abdominal wall, if *any* hæmorrhage be present, but not sufficient in amount to justify or indicate an enlargement of the wound for the purpose of applying a ligature to the bleeding vessel, the exit of the flowing blood through the orifice of the wound from the injured artery or vein should not be checked by outward applications. By far the less of two evils will be to allow the blood to escape externally, rather than by external appliances to ensure its accumulation in the tissues surrounding the wound. We would lay it down as a rule, secondly, that if hæmorrhage be at all free, the wound should be enlarged sufficiently to allow the bleeding vessel to be secured, and no dependence should be placed on pressure to restrain such hæmorrhage. We would also lay it down as a rule, thirdly, that with the earliest suspicion of suppuration the wound should be freely opened, and a ready escape afforded to the blood, serum, or pus now collected within.

The extent of a punctured wound will always to some degree regulate the subsequent amount of mischief. If it penetrates through the muscles, but not the peritonæum, the wound may prove fatal from peritonitis secondary to the suppurative stage, if not fatal from peritonitis the immediate result of the accident.

Under all circumstances, therefore, the utmost precaution in treatment is necessary. Perfect rest; relaxation of the abdominal muscles, by a posture somewhat bent forwards; the stomach and bowels to be kept moderately empty by the administration of fluid food only; and the administration of opium as indicated by symptoms, will constitute the chief points of medical management. The local treatment of the wound is not a consideration of importance here; if there be suppuration, *the point* beyond all doubt is, that it have free vent; irrespective of *that*, the treatment is of the simplest kind. Peritonitis supervening on these accidents cannot often be met by active or heroic treatment; leeches should not be spared if necessary and if the patient can bear the loss of blood. The practitioner will find in most cases an invaluable auxiliary in opium; but science, judgment, and experience must regulate the treatment in each individual case, according to symptoms. No definite law can be applied to the complications which so often arise in the progress of these cases.

Suppuration will be indicated by increase of heat about the wound, redness, tumefaction, and tenderness. These symptoms will soon be followed by heat of body, increase of pulse, thirst, a brownish dry tongue, rigors, and perhaps wandering sleep or delirium. It may even happen, if the wound be deep, and the symptoms severe, that the constitutional disturbance is so rapidly increased in amount that death takes place in an unexpectedly short period. It is well, at all times, to be very guarded in any opinion offered to the anxious relatives of a patient, the subject of such an accident. In rapidly fatal cases the cellular tissue and the fascial interspaces will usually be found infiltrated with pus and lymph to a surprising extent; and not unfrequently purulent effusion will be observed on the surface of the intestines.

Should the patient survive the early inflammatory and suppurative stages following a punctured wound of the abdominal wall, the suppurative action may spread at intervals in various directions, and abscess after abscess present in different positions until he becomes worn out and dies; or sometimes when the patient may be said to have placed his hand on the door leading to death's chamber, the symptoms commence to show a favourable turn. Suppuration becomes healthy in character and diminished in quantity. Sinuses gradually close, and time slowly replaces the sufferer in a position of safety; he rises from his couch convalescent, but most probably somewhat crippled, either from suppuration having extended below Poupart's ligament and having implicated the muscles of the thigh or neighbouring articulations, or from the contracted position in which, for many weary days, he has been confined to bed.

In the abdominal wall a condition sometimes remains, after a wound of the parietes has healed, to which the attention of the surgeon must be directed—we allude to the protrusion of the parietes at this part. This protrusion is the result of the action of the abdominal contents against the cicatrix, which thins out and yields more readily than the natural healthy abdominal wall. Such a protrusion constitutes one of the forms of ventral hernia. Usually the protruding viscera push before them evenly the now stretched cicatrix and surrounding tissues, so that the base of the prominence is larger in circumference than any other portion. There is no so-called neck to the cavity which contains the viscera, so that the latter run little risk of strangulation. No difficulty is encountered in an attempt to push back the contents of the prominent mass; the difficulty is to restrain the viscera from again bulging forward. As there is no danger of strangulation, it is only necessary to support the parts by means of a large pad and a well-adjusted bandage.

2. *Wounds of the abdomen, with protrusion of the bowels or portions of other viscera* through the aperture, are by no means rare accidents; such a protrusion constitutes a hernia without a sac.

The character of the wound will in a great measure regulate the amount of the protrusion, just as the situation of the wound will to some extent permit only certain viscera or portions of them to be protruded. In punctured and small wounds a part of the intestine, omentum, or both, may escape through the aperture. In incised or lacerated wounds larger portions of either, or both, and even portions of the stomach, liver, &c. may protrude externally. In the former kinds of wounds the protruding viscera are very apt to be constricted at their point of exit from the cavity of the abdomen; a condition little liable to happen in the lacerated or large incised wounds. The viscera most frequently met with protruding through wounds of the parietes of the abdomen are the small intestine and omentum; for as the mobility of the part, so is the greater facility of its displacement. But stomach, large intestine, and even liver and spleen, have been found lying outside the abdomen in wounds, the result of accidents such as we are about to consider.

We presume, as the first consideration in treatment, that the surgeon, in dealing with protrusion of any portion of the viscera through a wound of the abdomen, has a recent accident before him. In such a case he has no time to lose in returning the protrusion, whatever it may consist of, whether omentum, intestine, or other tissues. What considerations should guide his proceedings? In the first place, having by careful examination satisfied himself of what the protruded portion consists, he must see that no foreign substances adhere to, or are entangled in, the protrusion. If such be the case, the parts must, with gentleness and caution, be cleansed with tepid water, to free the peritonæum of all extraneous matter, and to secure a *perfectly* clean surface. If the portion protruded is *apparently* omentum alone, care must be taken to ascertain that bowel is not wrapped up in the folds, or lying at the base of the protrusion near the aperture of the wound. If the protrusion consist of intestine, care must be taken to ascertain that no injury has been occasioned to the peritonæum, or that the coats have not been ruptured. These points being ascertained, the parts being sound and healthy, and the surface perfectly clean and free from extraneous matter, the replacement of the protruded mass into the abdominal cavity should at once be proceeded with. A ready replacement is not always easily effected. In such a difficulty it will sometimes answer to draw out a small portion more of the intestine, and then on gently pressing upon it, and propelling its contents into the interior, the protruded bowel will itself sometimes readily follow. It may happen that such a large amount of intestine or omentum has escaped through the wound, that the protruded portions can no longer be passed back through the opening by which they escaped. Under such circumstances the surgeon need not hesitate; for as in a case of strangulated hernia, so here, the orifice, or stricture of the wound should be enlarged. If this alternative be inevitable, care must be taken to avoid enlarging more than the external orifice of the wound, or dividing more than any bands of fascia or fibres of muscles that offer obstruction to the return of the protrusion. The peritonæum should not be interfered with if this can possibly be avoided. The opening in the peritonæum will readily yield to any extension requisite for the reduction of the protruded viscus; but if the opening in the peritonæum be increased by incision, the enlarged wound will hereafter be found to facilitate, to a most troublesome degree, the reprotrusion of viscera through the peritonæal opening. The external opening being, either of itself or by extension, sufficient for the reduction to be proceeded with, the protruded parts should be gently returned, bowel first, and omentum after it, should both have escaped. The surgeon should then satisfy himself that all is fairly returned within the cavity of the peritonæum. The structures which protruded should not be heedlessly or hastily reduced, for they may be pushed simply between the external tissues and the peritonæum, without having been returned into the abdomen, and they would then still remain subject to the constricting influences of the internal orifice of the wound. In all cases, *subsequent* to the reduction of the parts, the finger of the surgeon should be gently passed down to the peritonæal aperture, to ascertain whether any portion of viscera still occupies this opening, in which case he should ensure perfect reduction previous to closing the wound.

Supposing omentum to be the only structure protruded through such a wound, something depends on the condition, something on the quantity extruded, and something upon the nature of the wound, before we can decide to return it into the abdomen. If the omentum be quite healthy, recently protruded, not congested, not lacerated—whether it be much or little in quantity—and if the wound permit of its ready return, there can be no doubt that, to return the mass at once, and to close the wound, is the practice we should adopt.

If the omentum be bruised, lacerated, dirty from contact with the ground or other material, inflamed or congested, or if the mass be not considerable, but there be much resistance to its reduction, without enlarging the wound, we would recommend a ligature to be passed round the base of the omentum, or a double thread to be passed through it, and each thread tied round it, and the mass anterior to the ligature cut off.

If the protruded mass be very large, and not injured, but the wound not sufficient to allow of a ready return, the wound should be enlarged, and the parts replaced; but if a large portion be in any degree bruised, lacerated, or congested, or if blood be extravasated in its structure, it may be removed with safety, and its removal will be probably less serious than if it were left in the wound to suppurate or slough, as the case may be. In very many cases of inguinal and femoral hernia, it has occurred to the author to consider it desirable to remove portions of omentum, occasionally considerable portions. He has never had reason to regret the adoption of such a proceeding, but has had occasionally to regret its omission. If such treatment be applicable in the one class of cases, we cannot reasonably condemn it in the other; and under the circumstances above mentioned, it appears to be the most judicious, and the most expeditious, towards favouring the recovery of the patient. It must, however, be stated that there are some differences of opinion on this point. The opinion now arrived at is the result of a careful consideration of the practice observed at St. George's Hospital for many years past. Be it remembered, however, that whether the omentum be returned, or whether removed, the external wound should be brought together at once, and should have nothing protruding between its lips, except the ends of the ligature passed round the omentum. The removal of omentum *must never be attempted under any circumstances*, without the base of the portion to be removed being safely secured by ligature. If this precaution be not heeded, very formidable, if not fatal, hæmorrhage may result from the vessels divided. And again, it is safer to pass the double ligature through the base of the omentum rather than trust to a single ligature tied round it; we thus avoid the possibility of the ligature escaping from off the stump of omentum, which is left in the wound after the greater portion of the protruded mass has been cut away.

With the exception of omentum, all other protrusions of viscera must be invariably reduced, and as early as possible.

It has been already stated that the small intestine is more frequently protruded than portions of other viscera, after wounds of the abdomen; the transverse colon and the stomach come next, each in its order. The wound of the parietes must be extensive to allow of the protrusion of liver or spleen. But yet there are cases on record, and those not few, which bear witness that portions of most of the viscera may escape through an opening in the abdominal wall. In a practical point of view it does not matter what the protrusion may consist of, irrespective of omentum; for, provided the mass be healthy, *it must be returned.* It is only the amount of the protrusion which will to some extent affect the steps of the treatment; for if the wound be small, and the mass protruded large, in all probability the former must be enlarged before the latter can be returned. In lacerated or incised wounds the probability is that reduction is readily effected.

The rules propounded respecting the propriety of reducing the omentum when protruded, will apply to some extent to the treatment of protruded intestine. The latter, when examined soon after an accident, may be found reducible readily through the wound. In such case the precautions necessary are, to see that the intestine is clean—its surface free from dirt, hairs, straw, or other matters which the contact of clothes, &c. may occasion to adhere to the moist peritoneal covering; that the bowel is not bruised or ruptured; that no portion of the instrument which occasioned the wound is lodged among the folds of the intestine. The surface of the bowel must be well cleared of all adherent materials, by being bathed gently with tepid water, and, if otherwise sound, be at once returned into the abdomen.

If the bowel, as regards its integrity, &c., be in a condition favourable for reduction, we may nevertheless find that it is irreducible. This circumstance may be the result of a great amount of viscera protruded, or of the protruded portion having become much distended by flatus, or thickened by congestion —or of a wound, contracted when compared with the size of the mass external to it. If the difficulty in reduction arises from the smallness of the wound, the means to be adopted have already been mentioned. If such difficulty depends on the distension of the bowel by flatus, that condition may often be overcome by very gently and carefully pressing the air back into the portion of intestine within the abdomen. This attempt, however, may entirely fail, and only by an extension of the wound can a very large mass of greatly-distended intestine be returned into the abdomen. In instances of very large protrusion, with *excessive distension*, to puncture the bowel with an exploring needle is a practice which has been adopted successfully; but, on the other hand, such practice has been strongly condemned by several writers. It has been urged that the small punctures cannot be of service, as they will soon be filled up by the mucous coat. However, as they are only wanted for immediate relief, this objection is not of much value. Such treatment can only be requisite in extensive protrusion of bowel largely distended, and where there is much difficulty of reduction.

Mr. Tatum reports a case in which he adopted this treatment with success. A patient was operated on for inguinal hernia, and the medical man found, after dividing the stricture, that so large a mass of bowel protruded that no effort on his part would succeed in reducing it. Mr. Tatum was called in, and examining the condition of the parts, found the space between the thighs occupied by a large volume of intestine, extending nearly down to the knees. 'It was found to be composed of the whole, with a slight exception, of the jejunum and ileum, enormously distended with flatus, and of a bright red colour.' With a grooved needle, Mr. Tatum made three or four punctures, allowing the flatus to escape by the groove in the needle at each puncture, until the part was collapsed. 'By these means the whole of the protruded bowel lay in a collapsed state, not one-fifth of its previous volume. The protruded parts were now readily returned into the abdomen;' and the patient recovered without a bad symptom.*

In all other conditions of irreducible intestine, the wound has to be enlarged before the attempt at reduction can be successful. Great care and much gentleness are requisite in handling a portion of bowel when the reduction is attempted; observing carefully the manner in which the coils of the bowels lie with regard to the wound, the surgeon should commence manipulation with the portion last descended, and nearest the margin of the opening; and should keep passing up portion after portion by degrees, until the whole mass is returned. This process, though apparently simple in its description, is often very perplexing at the bedside; such an attempt sometimes appears almost hopeless; for as one portion is pushed back, another portion is forced out of the abdomen. Every precaution is therefore requisite to lessen the muscular action of the parietes; the abdominal wall must be perfectly relaxed; the patient made to lie on his back, with his shoulders well raised, and the thighs perfectly flexed on the pelvis. If it be necessary to enlarge the wound, we should be careful to enlarge it in the direction of the muscular fibres, and away from the course of the epigastric artery, and to avoid enlarging the opening in the peritonæum if possible. It is necessary to ascertain that the bowel when reduced is returned entirely within the peritonæum.

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* 'Cases of Hernia, with Remarks,' by Thomas Tatum, *Medical Times and Gazette*, April 29, 1854, p. 433.

The bowel protruded may be not only irreducible, but it may, as occasionally in herniæ, be also strangulated: of course this condition occurs only when a patient has been left, for some time after the accident, without medical aid or relief. The amount of mischief to the bowel, resulting from the strangulation, must be our guide as to whether any *positive* benefit is likely to be derived from its reduction; but, short of a state of gangrene, it were better to return the bowel at once, and so secure the best chance for the recovery of the patient. The wound should at once be enlarged, and the protrusion returned. In a condition of gangrene, if the gut is returned into the cavity of the peritonæum, death must ensue. The only treatment which holds out a prospect of life, with so much mischief, is to open the bowel at once, to allow its contents to escape, and then to leave the intestine, now adherent to the margins of the wound, in undisturbed possession of its new attachments. An artificial anus will thus be established. We shall hereafter consider the treatment of this lesion.

The treatment of all wounds of the abdomen, after the reduction of protruded viscera, whatever the character of the latter, is simple enough. The parts around the wound must be relaxed, and this relaxation be maintained by position. It is desirable to close the wound at once, and, in most cases, sutures are to be preferred, to secure uniform apposition of the edges, as well as to maintain perfect support. In the application of the sutures, it is desirable that the peritonæum be included in their hold as well as the more superficial tissues. Such a proceeding should not be considered more dangerous than if the suture be simply confined to the superficial margins of the wound. By including the peritonæum, we secure the perfect apposition of its edges, and thus prevent the escape of intestine into the gap of the deeper part of the wound, and also to a great extent prevent the products of suppuration escaping into the cavity of the peritonæum. Whenever a ligature has been applied to the omentum, the ends of that ligature should be allowed to hang out of the wound, between any two sutures applied to its margin, until separation from the hold on the omentum takes place. The period of separation varies from nine or ten days to sometimes a fortnight or three weeks. The dressings applied to the wounds cannot be too simple or too light.

The following case is a fair specimen of recovery after a large lacerated wound of the abdomen. A man, whilst leading a prize-bull to an agricultural show, was suddenly attacked by the animal, and gored at the lower part of the abdomen. The patient was seen soon afterwards by Mr. James of Uxbridge, who found a large quantity of the small intestine and omentum protruding through a lacerated wound, some eight or nine inches in length, passing directly across the body, midway between the umbilicus and pubes. When seen first by Mr. James, the intestines were covered with dirt, and had adhering to their surface particles of straw, &c. The parts were carefully cleansed with tepid water, and all extraneous matter removed from the peritonæum; the intestines and omentum were then returned into the cavity of the peritonæum, and the edges of the wound brought together by several silk sutures. The man was then sent in a cart to St. George's Hospital, a distance of fifteen miles, and placed under Mr. Cutler's care. On the morning following admission, the wound looked perfectly united. There was some tenderness about the abdomen, but nothing of a severe character. The pulse was not irritable; the tongue rather white; but the patient stated himself to be pretty comfortable. He had not one bad symptom subsequently. The wound entirely united by first intention; and the man left the hospital in a short time quite well, and without any discomfort from the injury.

The stomach, portions of the liver, or the spleen, may escape through a wound in the abdominal wall, as we have already stated, but the principles laid down for the treatment of protruded intestine will, in a great measure, apply to these complications. Mr. S. Cooper mentions that in his part of the Military Hospital at Brussels, after the battle of Waterloo, the number of patients admitted with protrusions of the viscera was much more considerable than previously he had any idea of meeting with—protrusions of stomach, bladder, mesentery, omentum, and intestine.

Dr. John Macpherson, of the Bengal Medical Service, relates a case of spear-wound, with protrusion of liver, in a Hindoo. The wound was an inch in length; about three inches above the umbilicus, and about two inches to the right side. Through the wound, a triangular portion of liver protruded. There was much hæmorrhage, but no apparent wound of the liver. It was found impossible to return the protrusion without enlarging the wound. A ligature was tied round the base of the prominent piece of liver, and the greater portion cut off; a double ligature secured the remainder to the edge of the wound. The patient recovered.* We may remark that the natives of India are singularly happy in recovering after surgical operations.

Many other cases could be added to illustrate not only the possibility; but the fair prospect of recovery after wounds of the abdomen, with protrusion of viscera, provided the viscera are not injured nor the peritonæum bruised. The following case, however, is a marked instance of an unusual character of accident, as well as an illustration of a difficulty, which creates some kind of doubt as to the most advisable treatment to be adopted. For the notes of the case the author is indebted to his friend Mr. Godson, of Barnet. 'A woman, æt. 63, on July 11, 1854, was seriously injured by the brutality of four men committing rape upon her. The following morning she walked nearly a mile, with several convolutions of the small intestines protruding externally through a rent in the vagina. The intestines, when seen by Mr. Godson, had particles of straw and dirt adhering to their surface, but the woman did not appear to suffer very much pain, though apparently very ill. The parts were cleansed with tepid water, and the patient was put to bed in the workhouse. Mr. J. H. Green subsequently saw the patient, in consultation with Mr. Godson. All attempts at reduction were found unavailing; nor did there appear any possibility of enlarging the wound to facilitate the reduction of the bowel. The protruded portion became gangrenous on the 14th, but the patient lived until the 21st, ten days after the injury. The rent was found in the anterior wall of the vagina, close to the uterus, and running into the cavity of the peritonæum between the bladder and uterus.'

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* *Medical Gazette*, Jan. 1846.

It is somewhat difficult to advise what proceedings should be adopted in any case similar to the above. There appeared no possibility of returning the bowel by manipulating the protrusion itself; nor did it appear possible to get at the opening to enlarge it, the vagina being filled with intestine. The treatment which appears most suited to such a case, and which should be adopted if the result of this case is to influence us, would be to make an incision through the abdominal wall in the median line and below the umbilicus, and to introduce the hand, so that the bowel might through this opening be drawn back into the abdomen from the vagina. The treatment would be desperate; but without some effort at reduction such a case is hopeless. Such treatment ought only to be adopted as a last resource, and only after the failure of local attempts at reduction, assisted by raising the lower part of the trunk, so as almost to place the patient with the head below and the pelvis above.

Protrusions of the spleen have been recorded as successfully treated, either by reduction, or even by removal. One singular case of the latter description is to be found in the *Phil. Trans.* vol. xl. p. 425, in which instance the patient recovered, and lived without apparent suffering from the loss.

In protrusions of the bladder, it is always requisite to introduce a catheter through the urethra without loss of time, and to draw off the urine. This treatment will, we believe, in all cases sufficiently reduce the size of the protrusion to permit its reduction without difficulty.

The latter protrusion may occur subsequent to a wound of the abdominal wall without a wound of the peritonæum. The protrusion will only occur, under any condition of wound, when the bladder is somewhat distended, for an empty bladder lies behind the pubes in close contact with the anterior bony wall of the pelvis. Provided there be no injury to the bladder, the simple protrusion, unaccompanied by peritonæal injury, is an accident that may produce very little subsequent inconvenience, even if the whole of the external wound does not unite immediately. If a wound of the lower portion of the abdomen be complicated with wounded peritonæum, and a punctured bladder permit the escape of urine into the sac of the peritonæum, severe peritonitis rapidly follows upon the injury, and death soon takes place. The further consideration of lesions of the bladder will be found under the head of INJURIES OF THE PELVIS.

Before concluding this portion of the subject, it may be mentioned that occasionally, but rarely, subsequent to a wound of the abdomen, peritonitis may terminate in the formation of an abscess, confined to a proportionately small space in the peritonæal sac, and that such abscess may of itself open externally, or require the aid of the knife to allow of the exit of matter. We can rarely anticipate a favourable result in such a case; for we should generally find the intestines matted together in the neighbourhood of the abscess, and frequently a fistulous communication established between the abscess and the intestines forming a portion of the circumference of the sac. In such cases suppuration and diarrhœa play upon a system already reduced by previous illness, and the patient sooner or later sinks under the exhausting influences of the local mischief and constitutional disturbance.

3. *Wounds of viscera* may be classed, for the convenience of consideration, into, firstly, those which occur in protruded portions; secondly, those which occur from penetrating wounds of the abdomen.

In the examination of the first-mentioned variety, we have here to consider the nature and treatment of *the wound alone.* All that relates to the management of the protruded bowel has already been fully discussed, and requires no recapitulation.

Wounds of the intestine may vary very considerably in size as well as in appearance, according to the shape and character of the instrument by which the lesion is occasioned; and the treatment must be regulated very much according to the extent of the wound.

A small wound of the bowel, whether of the small or large intestine, produced by some pointed instrument, or by a sharp knife, when seen *immediately* after the injury, would present little more than the wound in the peritonæum, for the deeper gap would almost instantaneously be filled with mucous membrane. The fæces are not observed to escape through so small a wound. In a very short time after the receipt of the injury, the entire wound would be found plugged with mucous membrane, and the latter would soon project above the level of the surface of the peritonæum, become everted over its margin, and thus effectually conceal the exact limits of its orifice. A pair of forceps applied to the intestine at the injured part will enable the surgeon to raise up this portion, and pass a very fine ligature immediately round the puncture, so as to include it entirely. The ligature should then be tied firmly, and the ends cut off close to the knot. The bowel should be returned as directed.

Some surgeons have considered it unnecessary, and not even desirable, to apply a ligature round *a small punctured wound of intestine.* They have argued that the mucous membrane so entirely blocks up the orifice in such a wound that escape of the contents does not occur, and that the application of the ligature is only apt to aggravate the tendency to peritonitis. But it must be evident that the application of a ligature to a wound, however small, of the intestine will entirely prevent the escape of any fæculent fluid into the peritonæum, and thus will constitute one great measure of safety in treatment; nor is it at all evident that the presence of the ligature is prejudicial. The adoption of such practice has been successful in very many instances.

Mr. Travers, in his work on *Injuries of the Intestines*, has recorded several experiments on animals, the results of which tend to prove that a wound of the peritonæum, complicated with a wound of the intestine, is generally fatal from the effects of peritonitis. All the experiments by Mr. Travers, Dr. Gross, and others, lead to this conclusion, that, upon the infliction of a wound of the intestine, *some* escape of fæculent fluid, though perhaps a very small quantity, takes place, and is the chief cause of the subsequent peritonitis. The escape of the very smallest quantity of such a fluid appears sufficient to produce violent peritonitis; and it appears, therefore, more just to ascribe the peritonitis following a wound of the abdomen, complicated with a wound of the intestine, to some escape from the latter rather than attribute the mischief to the wound of the peritonæum.

A simple wound of the peritonæum without a corresponding opening in the intestine is a far less serious injury in its consequences than may generally be supposed. Surgeons experienced in operations for strangulated hernia are quite familiar with the following facts: that patients operated on *early in the period of strangulation*, in a very large proportion of cases recover with singularly little inconvenience, and with remarkably slight symptoms; but that the fatality attending operations for strangulated hernia is almost entirely to be attributed to mischief occasioned to the intestine *by delay*, or by unnecessary force applied to the hernia in prolonged, sometimes violent, attempts at reduction previous to operation. The simple wound of the peritonæum is generally considered as by far the most unimportant condition in the treatment of a case of strangulated hernia.

A case of femoral aneurism, under the care of the late Mr. Keate, in St. George's Hospital, was treated by ligature of the external iliac artery. The peritonæum was accidentally wounded in the operation, to the extent of about an inch. The patient died a few days after the operation, from causes unconnected with this wound. On examination, the wound of the peritonæum was found perfectly united; there was not the slightest evidence of peritonitis, or any effusion of fluid within the cavity of the peritonæum.

A simple wound of the peritonæum need not, therefore, be considered as necessarily productive of fatal peritonitis.

The management of a *large wound* in a protruded portion of intestine is quite a different matter from that of a small wound, and the treatment should also be regulated somewhat by the manner in which the intestine is wounded; viz. whether it be cut more or less across, or whether it be entirely divided. 'Before adverting to the consequences of wounds inflicted on the exposed intestine,' observes Mr. Travers, 'it will be necessary to describe certain appearances, which the wounds exhibit, depending upon the action of the bowel. If a gut be punctured, the elasticity of the peritonæum and the contraction of the muscular fibres open the wound, and the villous or mucous coat forms a sort of hernial protrusion, and obliterates the aperture. If an incised wound be made, the edges are drawn asunder and reverted, so that the mucous coat is elevated in the form of a fleshy lip. If the section be transverse, the lip is broad and bulbous, and acquires tumefaction and redness from the contraction of the circular fibres behind it, which produces relatively to the everted portion the appearance of a cervix. If the incision is according to the length of the cylinder the lip is narrow, and the contraction of the adjacent longitudinal, resisting that of the circular fibres, gives the orifice an oval form.'* We have no choice of treatment when called to a case of a large wound of the intestine;—we should close that wound by suture, and return the bowel into the abdomen as quickly as possible. Some little fancy may be exercised in the choice of suture; but *that* is a minor consideration. 'I am not aware,' says Mr. Travers, 'that any formal directions are required for the operation of sewing up a wound of the intestine. Let a small round sewing-needle, armed with a silk thread, be passed near to the lines formed at the bases of the everted lips. The thread is to be carried, at short regular distances, through the whole extent of the wound; the operator being mindful that an equal portion of the edges is included in each stitch. When the suture is finished let the thread be securely fastened, and cut close to the knot.'† The main object in view, in the application of the sutures, is the most perfect adaptation of the edges of the wounded intestine, so that extravasation of its contents be effectually prevented. The intestine is to be returned to its natural bed, without any measures being adopted to retain the wounded portion near the external wound. *No ligature should be used for such a purpose.* The treatment of the internal wound is thus independent and quite distinct from that of the external one. The latter, on the replacement of the bowel, is to be managed as if no other injury had occurred.

When the entire cylinder of the bowel is divided, the case is far more serious. A vast number of experiments have been made to establish some definite rule in the treatment of such extensive injuries: any relation of these experiments would occupy too much of our space without any beneficial return; and it is therefore necessary merely to confine our remarks to the most practical observations that bear upon this subject. Mr. Travers states that the retraction ensuing upon direct division of the intestine 'renders this injury irreparable.' But there are on record some few cases of complete division of the bowel in which recovery is stated to have taken place. The condition of the extremities of the divided portion, will, in some measure, resemble the margins of a small wound in the intestine, viz. the mucous membrane will protrude from the open extremities and fold over the peritonæal surface; so that, when the divided portions are brought together, the two opposed surfaces will consist of two surfaces of mucous membrane touching each other. This latter fact has originated numerous theories respecting the treatment of these injuries, and has led to the performance of innumerable experiments on animals, with a view to ascertain the most effectual means by which this *supposed* difficulty might be overcome: viz. that two mucous surfaces in contact with each other could not unite. The results of these experiments have been that some surgeons have recommended sutures to be applied in such a manner that the mucous surfaces should be turned in, and the serous surfaces alone brought into contact. Others have invaginated the upper into the lower portion of the divided bowel; and various other devices have been advocated to ensure contact and union. But the main fact has, in most of these speculations, been entirely lost sight of: viz. that if the margins of each end of the divided bowel are but accurately adjusted to each other, and maintained in perfect apposition by sutures (whether the mucous or serous surfaces be made to touch), the divided portions are united at first, *not* by any act of union *between* the surfaces in contact, but by the effusion of fibrine around the once separated but now approximated and contiguous extremities; and thus does this fibrine not only maintain their conjunction, but it also, by adhesions, fixes the injured portion of the bowel to the adjacent surfaces of peritonæum, either visceral or parietal. When the surgeon finds that a wound of the bowel amounts to entire division of the gut, he may at once fix the divided portions in contact with each other with silk sutures, and then return the intestine into the abdomen. Or else he should lose no time in securing the edges of the wound of the intestine to the margin of the external one, so as to facilitate the formation of adhesions between the adjacent surfaces of both, and to prevent the possibility of any fæculent contents escaping into the peritonæal cavity. In complete division of the bowel, such treatment is to be preferred. Its effect is necessarily the establishment of an artificial anus in the first instance.* The following points should guide us in the choice between these two methods of dealing with an entire division of the intestine: that, if the division be caused by a clean sharp instrument, the extremities may be brought entirely together with sutures; but if the separation be the result of an irregular lacerated wound, as from gun-shot, &c., then we should not hesitate to fix the edges to the external wound, and risk the chance of an artificial anus.

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* Travers *On Injuries of Intestines*, p. 85.

† Mr. Travers has proved, by experiment, that 'the absolute contact of the everted surfaces' is requisite to avoid the risk of abdominal effusion.

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* The treatment of artificial anus forms a separate section.

If the divided extremities be brought together by sutures, and replaced in the abdomen, the injured portion of bowel need not be retained by ligature at the external wound, for, as a general rule, the one has been found to remain in contact with the other; and when perfect occlusion of the cut surfaces has not occurred, but some escape of the contents of the bowel taken place, that effusion has passed through the external wound; the adhesions within have prevented internal extravasation.

Let us now consider by what steps reparation occurs in a wound of the intestine, subsequent to the application of ligature or sutures. The results of all recorded experiments prove *this*: that there rapidly takes place an effusion of fibrine on the surface of the peritonæum around the wound. This effused fibrine soon agglutinates the wounded portion of intestine to the adjacent surface of peritonæum, and thus covers in the suture, and shuts it out from the general cavity of the peritonæum. The ligature or suture applied to the wound in the mean time has commenced to destroy the small portion of bowel which is surrounded by the silk—that portion of the gut is either killed by the ligature, or all the coats ulcerate through, in consequence of the action of the suture. The death of the part in the first, or the ulceration of the part in the second instance, are processes which travel from without *towards* the *interior* of the bowel. *Exteriorly*, either process is limited by the effused lymph. *Internally*, there is nothing to stay either one or the other. Either is continued until death of the part, or the act of destruction (ulceration) is completed. The mucous lining of the intestine is included with the other coats in the grasp of the silk ligature or suture; and when the last remaining portion of the wall has been cut through by the action of one or the other, the knotted silk drops into the bowel and passes away with its contents.

Thus much, therefore, is evident: first, that, soon after the application of a ligature or suture to any portion of intestine, fibrine is effused on its surface, and the ligature becomes thus shut out from the peritonæal sac; secondly, the ligature equally soon commences to destroy that portion of bowel which is surrounded by the silk; thirdly, that, as the mucous membrane (forming one of the layers of that portion) dies, or ulcerates, it opens inwards a path of escape for the ligature, which is only complete when each coat of the bit of intestine is entirely cut through; and, fourthly, that this path opens *into* the bowel, not *from* it.

Mr. Travers tied a ligature round the duodenum of a dog, so as completely to obstruct the intestine. This was returned into the abdomen, and the wound closed. On the fifth day, the dog passed a copious stool; and he recovered entirely from all effects of the ligature. He was killed on the fifteenth day. The wound of the duodenum, produced by the ligature, was entirely closed. Omentum was adherent to the surface at the part to which the ligature had been applied. The gut, when laid open, was marked by a transverse fissure at the seat of ligature. The ligature had passed away entirely.* The wound is thus closed; the ligature has escaped; and the injured portion of bowel is adherent to the abdominal wall, or some adjacent viscera. What has become of the everted edges of the mucous membrane? Are the surfaces united, face to face, or so inverted as to allow the wounded intestine to unite at its edges? Mr. Travers was evidently not satisfied on this point. He observes, 'The opposed villous surfaces, so far as my observation goes, neither adhere nor become consolidated by granulation; so that the interstice marking the division, internally, is probably never obliterated.'

Observation of wounds in mucous membranes of other parts does not allow the author to agree with these remarks; nor does Mr. Travers appear to have had *positive* evidence to enable him to decide unhesitatingly that such union *could* not, or *did* not, occur. Drs. Gross and Peterquin arrived at the conclusion that union *does* occur between the edges of the divided mucous membrane, and that the former position of the gap, after a time, is only indicated by a line of cicatrix.

The treatment subsequent to the replacement of the injured intestine should be similar to that sketched out in our observations on wounds of the abdomen. Punctures or wounds of the intestine must always be considered as very dangerous in their character, and are very frequently fatal in their result; and an entire division of the bowel is generally fatal.

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* Travers *On Injuries of Intestines*, p. 99.

Wounds of the stomach, with protrusion, are much more rare than wounds of the intestines. The treatment of wounds of the stomach should be guided by principles similar to those which apply to wounds of intestines: though, if the wound be large, it would be best to secure its edges to the external one, rather than apply sutures and simply return the protruded portion into the abdomen. A large wound so treated would, for a time at least, be followed by gastric fistula.

Wounds of the viscera which occur in penetrating wounds through the abdominal wall, may be said to be decidedly more formidable than those just considered.

Punctured wounds of the stomach or intestines, if small, are not necessarily followed by effusion. If the stomach be empty, in all probability effusion will not take place. Inflammation rapidly causes the aperture to adhere to some adjacent surface of peritonæum, and thus occludes the opening on the peritoneal surface. If the stomach be full, extravasation of its contents into the cavity of the peritonæum is apt to occur; but this complication need not necessarily take place, for vomiting rapidly supervenes upon wounds of the stomach, and soon empties it of its contents; blood would be mixed with the fluid thrown up, or large quantities of blood alone vomited. With escape of the contents into the peritonæum, there would follow all the most severe symptoms described in cases of rupture of the stomach. If the wound be across the lesser or greater curvature, very abundant hæmorrhage will be present, either into the stomach, or into the peritonæal sac. The danger in a wound of the stomach is greatly lessened when its contents are observed to escape externally; and though, in such cases, life hangs by a thread, instances have occurred of such wounds terminating in gastric fistulæ, from union of the margins of the internal with the external opening; so that the patient survived the accident.

Dr. Marcet has several times succeeded in establishing gastric fistulæ, by opening the abdomen of dogs, and drawing the surface of the stomach to the wound, and there fixing the coats with sutures; an opening then made into the stomach allowed a silver tube to be introduced and made fast in the opening. The care with which the operation is performed in a great measure influences the recovery of the animal; it is requisite not to disturb the parts much, and not to allow the escape of the least portion of the contents of the stomach into the peritonæum, otherwise the animal dies. Dr. Marcet states, that it requires a strong, hardy animal to recover from this operation; and generally, when recovery has taken place, the animal does not appear to be worse for the fistula: escape of the gastric fluid is controlled by a cork inserted into the silver tube. The latter is fastened into the wound, most effectually, by an ingenious method adopted by Dr. Marcet. Two dogs, in each of whose stomachs a fistula had been formed, survived more than twelve months, and appeared healthy and in good condition.

It will always be difficult to determine whether the stomach is implicated in a penetrating wound, unless there be escape of the contents through the external wound, or there be blood vomited. The treatment, therefore, must depend on the symptoms. No interference should be permitted with the external wound, if the contents are passing through it. The stomach should be kept empty, and the patient nourished entirely by enemata of beef-tea or soup. If there be no evidence of escape of the contents, but if it be suspected that the latter have passed into the peritonæum, as evidenced by the severity of pain and other symptoms, no treatment is available to save life; and, in such a case, we have only to endeavour to mitigate suffering.

Punctured wounds of the intestines from penetration of the abdominal wall by a sharp instrument, are not so serious as similar wounds of the stomach. Such small wounds do not generally permit extravasation of the contents, as the opening is soon plugged by the mucous membrane. But larger wounds are much more fatal, unless the internal wound be in apposition with the external one, so that the contents of the bowel may escape externally. In such a case, the wound should not be interfered with. Artificial anus for a time may be established, and so far immediate danger is lessened, if not removed. It is impossible to determine what portion of bowel may have been wounded in a penetrating wound of the belly, or whether several portions are not implicated in the injury. The external wound is no guide to us in this respect. If the wound of the intestine be very small, there may occur but very slight symptoms to indicate its existence; but if large, or if there be several wounds, then blood will probably be observed in the motions; and pain, vomiting, and other severe symptoms, will soon indicate the alarming character of the local damage. As a rule, wounds of the small intestine are more serious, *cæteris paribus*, than wounds of the large. In a wound of the latter, the escape of the contents externally is more probable, and more ready, on account of the movements of the bowel being much limited, and the aperture consequently more fixed. The escape of fæcal matter into the peritonæum depends much on the state of the bowel; even with a large wound in an empty intestine, Mr. Travers found that extravasation did not necessarily occur at the time of the injury. With regard to the treatment of wounds of the intestine within the abdomen, whether punctured, or incised, or lacerated (gunshot), we need say little more than that great attention is to be paid to the external wound. Any hope of recovery rests in the chances that, if the wound of the intestine be small, no escape of contents will have occurred: or if the wound be large, that the escape will be external. If the first condition be suspected, we need only simply dress the external wound. If the second be manifest, the external wound *must* be left open,—it is the safety-valve of life in such an injury,—and its premature closure might most unexpectedly and rapidly cause the death of the patient.

Wounds of the liver, spleen, and kidney are dangerous, in proportion to the amount of hæmorrhage, rather than from other circumstances. As it would be impossible to determine the fact of injury of either the liver or spleen in a punctured wound, we need not enter further into the question, beyond stating thus much, that, if *hæmorrhage* be not fatal, there is no reason the patient should not recover. Hæmorrhage will be indicated by collapse, &c.

Wounds of the kidney or bladder will be suspected from blood in the urine. When the latter viscus is injured, as a rule, the case will prove fatal if urine has entered the sac of the peritonæum. See INJURIES OF THE PELVIS.

In concluding his remarks on this portion of the subject, which embraces the consideration of wounds of the viscera, the effects of those wounds, and their treatment, the author ventures to hope that the reader will derive some assistance from the following general summary—a kind of index of results attendant upon these injuries:

1. That a rupture of stomach or intestine, *without external*

wound, is a fatal lesion; more fatal than when lesion of either viscus occurs *with external wound.*

2. That when rupture of liver or spleen is fatal, death is generally the result of hæmorrhage. Rupture of the gall-bladder is always fatal.

3. That when rupture of the kidney proves fatal, death, when occurring early, is the result of hæmorrhage; when occurring later, is the result of extravasation of urine.

4. That recovery from rupture of the liver, spleen, or kidney, is not improbable nor uncommon.

5. That a wound of the peritonæum, without bruise or laceration of tissues, is by no means necessarily fatal.

6. That a protrusion of intestine, or portion of other viscera, if the protruded part be not bruised, nor long exposed, need not necessarily prove fatal.

7. That a wound of protruded intestine or stomach, if small, should be secured by ligature—if large, by sutures; and the protruded viscus returned into the abdomen. The former lesion may terminate in recovery; 'but wounds amounting to direct division of the canal are irreparable,'* unless artificial anus be established.

8. That a punctured wound of viscera is more dangerous than a wound with protrusion—less dangerous than rupture without external wound; that the danger is in proportion to the size of the internal wound; and that an artificial anus offers the best prospect of recovery when the wound is extensive.

Fistula of the Stomach.

Hennen, in his work on *Military Surgery*, observes, that 'wounds of the stomach are extremely dangerous, though not mortal;' and he adds, that, according to M. Percy's observations, only four or five out of twenty recover. We have already alluded to the prospect of recovery after a wound of the stomach. Recovery may, in the first instance, occur from immediate blocking up of the internal wound, and union of the external one by first intention; or recovery may be qualified to this extent, that the two wounds become soon united to each other by their margins, but leave an opening through the walls of the stomach and the external parts. An escape of the contents of the stomach takes place through this opening, which may continue stationary for an indefinite time; such an opening constitutes a *gastric fistula*—fistula ventriculi externa; and we now propose to consider its conditions and treatment.

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* Travers, p. 133.

That the occurrence of a gastric fistula, or its persistence, is not incompatible with life, or even health, is a fact so satisfactorily authenticated, that it requires no confirmation on our part to establish it. We shall have to refer to cases which afford ample and conclusive evidence, not only of the formation, but the duration of these fistulæ over many years. A fistula of the stomach occurs on the escape of its contents externally, through a lacerated or incised or punctured wound, after the internal and external wounds have become blended by their margins into one opening; or the fistula may be the result of ulceration of the stomach, followed by adhesion of the opposed peritonæal surfaces, and ultimate perforation of the abdominal wall; or the consequence of a foreign body making its way through the visceral and abdominal parietes; or the result of abscess; or the effect of malignant ulceration.

When the wound, which allows the escape of fluid and food from the stomach, has become clean and healthy, granulation slowly produces a continuous smooth cicatrix between the outer skin and inner mucous surface of the stomach. This is, however, generally rather a tedious process, the cicatrisation being frequently interrupted by painful excoriation and ulceration, caused by the excessively irritating quality of the fluids constantly oozing out. But for a time the opening gradually contracts. If originally small, it may close in the course of a few weeks; if not small, it will probably remain open many months; —it may remain fistulous for many years.

The first difficulty with which the surgeon most probably will have to contend, will be the escape of the food; the second, will be the prolapse of the mucous membrane. The escape of the food will depend, in amount, on the size of the opening; the loss may be so great, that sustenance becomes a question of moment; and then recourse must be had to nourishing enemata. It is never desirable to plug the fistula to prevent escape of food, for the action of the plug is invariably to dilate the opening. A compress over the opening is the best application for the purpose of moderating the escape; and sometimes this treatment will succeed almost entirely in effecting the desired object.

The prolapse of the mucous membrane will depend very much on the size of the opening, as also somewhat on the part of the stomach implicated in the fistula. If the opening be in the upper portion of the large extremity, the prolapse will probably be but slight; whereas if the opening be towards the lower part, or pyloric extremity, the protrusion will be more troublesome. However, prolapse of the mucous membrane does not generally offer any difficulty in treatment; it is usually readily returned, but requires slight pressure to keep it from escaping through the fistula.

The following well-known case so well illustrates the points above alluded to, that we cannot help introducing it shortly, for that purpose. Alexis St.-Martin, aged eighteen, was wounded by a musket on the left side, when about a yard from the muzzle. The shot blew off the integuments and muscles, to the size of the hand, fractured and carried away the anterior half of the sixth rib, fractured the fifth rib, lacerated the lower part of the left lung and the diaphragm, and perforated the stomach. On the sloughs separating, a perforation large enough to admit the middle finger was observed in the stomach (besides other injuries, which do not bear on this question). *For seventeen days everything swallowed passed out through the wound*; and the patient was kept alive chiefly by nourishing injections. At every dressing of the wound, the contents of the stomach flowed out; its coats frequently became everted, or protruded so far as to equal in size a hen's egg, but were easily returned. After the fourth week the lad's health was quite restored. For some months the food could be retained only by wearing a compress and bandage; then a small fold or doubling of the villous coat began to appear, which gradually increased till it filled the aperture and acted as a valve, while it admitted of being pushed back by the finger from without. The wound was inflicted in June 1822, and St.-Martin was alive in March 1833. The orifice of the wound was then in the same state as in 1824, being about two inches and a half in circumference. When the stomach was entirely empty, the valve was generally forced out through the orifice, together with a portion of the mucous membrane equal in bulk to a hen's egg. After he had slept for a few hours on the left side, the protruded portion became so much larger as to spread over the neighbouring integument five or six inches in circumference, and fairly exhibited the natural rugæ, villous membrane, and mucous coat lining the gastric cavity.*

In the *Med.-Chir. Trans.* vol. xli., a case is related by Dr. Murchison, of a woman aged thirty-four, in whom a fistula was occasioned by the continued pressure of a copper coin over the epigastric region; ulceration was set up; and the pressure, constantly applied to the surface of the ulcer, at last effected a communication from without into the cavity of the stomach. Dr. Murchison has added to the particulars of this case a short table of cases of gastric fistulæ, many of them the result of disease commencing from within.

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* For the further interesting particulars of this case, we must refer our readers to Dr. Beaumont's *Experiments and Observations on the Gastric Juice, and the Physiology of Digestion.*

The treatment of a gastric fistula should, in the early days of its occurrence, be most simple. The parts should be kept scrupulously clean, and the compress and bandage and other dressings frequently changed; lint, moistened with tepid water, is the simplest and most cleanly dressing, and should be used as soon as the wound has commenced to granulate; and as long as there is any tendency to contraction nature should be permitted to pursue her course unmolested. Frequently, such fistulæ will close without our interference.

When all further prospect of closure is at an end, when contraction of the orifice of the fistula appears to have been carried to the utmost, and the fistula indicates that, without some surgical assistance, it may remain patulous for the period of the patient's life, then it becomes the duty of the surgeon to endeavour to assist in the closure of the orifice; otherwise the fistula will last for years. Richerand mentions one extending over a period of nine years. In Haller's *Dissertations* two cases are recorded, one by Etmuller, in which the fistula continued open for ten years; another by Wenker, in which it remained patulous for twenty-seven years. Under such prospects the presence of a gastric fistula becomes a grave evil, and all practicable efforts should be made to relieve the patient. The prospect of closure held out by a plastic operation is such, that we may attempt by repeated operations to close the orifice, even should the first prove unsuccessful. Dr. Middeldorpff * has related a case, in which he lately succeeded in almost entirely closing a gastric fistula (apparently the result of some ulcerative process in the stomach), which had existed some five years. A flap of skin was brought up from the lower extremity of the opening, and fixed to its edges by sutures. The whole of the surfaces united, with the exception of a point the size of half a pin's head. As this fistula happened to be situated between the cartilages of the sixth and seventh ribs on the left side, it was in an unfavourable position for contraction, and in an equally unfavourable part for the success of any attempts made to close it. The almost complete success of Dr. Middeldorpff is very encouraging, under the circumstances of the case he has related; and should lead us to anticipate complete relief from a similar operation, were the fistula situated below the cartilages of the ribs, and in a situation in which the tissues yield more readily. Sometimes one or two sinuses burrow round an abdominal fistula; should such exist they should be laid open before the attempt is made to close the principal artificial aperture.

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* *Brit. and For. Med.-Chir. Rev.* Oct. 1860, p. 545, from the *Wiener Wochenschrift,* Nos. 3–6.

Fistulæ of the gall-bladder may be the result of abscess caused by the presence of a gall-stone. Such cases are very rare, nor do they require much more than a passing notice. Before such a fistula can form, the patient must have had pretty marked evidence of previous mischief in the neighbourhood of the liver and gall-bladder, with constitutional disturbance of no slight character. The treatment, as far as the surgeon is concerned, should be, to give exit to matter as soon as local evidence of its collection is in any degree marked, or its existence suspected. Should a gall-stone be lodged in the abscess, or present at the opening, some degree of caution is necessary in interfering with it; but the sooner it can be removed without risk, the earlier will be the relief afforded to the patient, and the sooner will the parts commence to recover. There may remain a fistula with bile escaping from it for some time, but unless there be some marked reason for surgical interference, it were better to leave the parts to contract of themselves.

ARTIFICIAL ANUS.

Artificial anus 'generally results from loss of substance consequent on mortification of the bowel in strangulated hernia, but may be the consequence of penetrating wounds, or of ulceration of the canal from internal or external causes.'* Whether artificial anus be the result of accident or disease or operation, the conditions which the opening may assume, or the treatment to be adopted for its relief, in either case cannot vary to any great extent. We therefore propose to consider the evil under both aspects.

As in lesions of the stomach, so in fistulous apertures of the intestine, there may be a small or large permanent opening, established by the union of the sides of the internal wound with the circumference of the wound in the abdominal parietes. But the size of the fistulous orifice, through which escape of fæculent fluid takes place, will depend entirely on the amount of destruction of the intestinal wall, not at all on the original size of the external wound. In proportion to the loss of the former, there will be experienced a difficulty in closing the latter, and in proportion to the distance of the common orifice from the pylorus will the chance of immediately saving or of prolonging life be increased. For the purpose of considering the general features of an artificial anus in its early condition, we will assume that, whether the fistula be the result of wound, or mortified bowel, or other cause, the orifice in the bowel has become fixed to the margins of the external aperture; that all sloughs caused by injury or disease have become separated; and that there is, at the opening, a continuous surface from the integument without to the bowel within. What characteristics may we expect to find about such an opening? Usually the aperture will be more or less round, but it may be oblong and irregular. The smaller it is, as a rule, the more circular will be its shape. The margin will seldom present a smooth or healed condition, but will often be somewhat puckered, and more often excoriated and bleeding. The skin surrounding the aperture will generally be much irritated, sometimes quite sore, and often very sensitive or exquisitely painful; all which is the result of the irritating matters escaping from the gut and running over the integuments round the fistula. As the orifice of the fistula contracts, the surrounding skin is thrown into slight ridges; the furrows between which become sometimes deeply ulcerated. The condition of the orifice itself will depend much on the size of the opening; if small, the mucous membrane will generally be observed at the bottom of the orifice, and a constant oozing of fæculent matter and intestinal mucus will persist as long as the orifice remains.

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* Lawrence *On Hernia,* p. 379.

If the orifice is large, some amount of prolapse will constantly occur through the fistula; but when the intestine retains its proper position within the abdomen, from the posterior wall of the fistula will be observed a fold of membrane—its thin edge projecting towards the outlet. If the destruction of the bowel has been extensive; for instance, if the bowel has been divided, and the divided extremities have become attached to the external wound; or if three-fourths of the wall of the intestine has been lost by slough, or shot away, and artificial anus has been formed, then we shall be able to observe distinctly the upper and lower orifices of the bowel, and between them the fold of mucous membrane will be seen projecting almost to the level of the external outlet; in fact, so as to form a distinct and prominent partition which extends from behind forwards, between the openings of the upper and lower portions of the gut. In proportion to the projection of this fold into the wound, so is the obstruction to the passage of the contents from one opening to the other. The fold may even, and often does, project sufficiently to lap over the lower opening, and then will conduct the whole of the contents of the upper division of the bowel directly outwards through the artificial anus. The fold, to which we have now drawn attention, constitutes an important feature in the ultimate condition and in the treatment of artificial anus; to this fact we shall refer presently.

Such, then, are the general external characteristics of artificial anus. We have now to examine the conditions, within the abdomen, of the portion of bowel implicated in the opening. If we trace a convolution of the upper portion of the intestine towards such an aperture, on approaching the latter, the bowel will be observed, within the last few inches, to form an angle more or less acute with the portion of intestine which forms the commencement of the lower division. According to the amount of destruction of the bowel, and the prominence of the fold of mucous membrane within the wound, will be the acuteness of the internal angle; and if the angle be very acute, in consequence of extensive destruction, the portions of bowel forming the angle will lie more or less side by side, or sometimes across each other, as they approach the fistula. The serous surfaces of these opposed portions are not generally adherent to each other. Intestinal convolutions may dip down between them, and even push forwards a serous sac into the artificial opening. This is an important fact,—viz. that the mass of intestine within the abdomen is only protected externally, at the artificial opening, by the thickness of the wall of the adherent bowel. The serous surface of the intestine, where the latter is adherent to the abdominal wall, is continuous with the parietal peritonæum all round the false opening; for the two serous surfaces, parietal and visceral, have become adherent to each other, either previous to the sloughing of the bowel in a hernia, or subsequent to the wound of the intestine in an injury. The adhesions, which unite the intestinal to the external orifice, occur first on the peritonæal face of each opening, and are at first slight, but subsequently become more firm as they become vitalised. But the extent of such adhesions is never broad, nor capable of offering much resistance to the pressure of the viscera within. Sir W. Lawrence justly observes, 'The abdominal cavity is protected at the margin of the opening by a feeble barrier; the extent of the adhesions being only from half a line to a line, sometimes, but rarely, reaching to half an inch.'* As the membrane covering the bowel attached to the orifice is thus continuous with the parietal peritonæum within, so the membrane lining the bowel is continuous with the cuticle which surrounds the artificial anus without.

Such, then, are the general and early conditions usually found in a case of artificial anus; certain variations may be met with, dependent on locality. In an artificial anus, the result of an accidental wound of the large intestine, or the consequence of an opening made into the colon in the lumbar region for the relief of obstructed bowel, the probability is, that no fold of mucous membrane will exist, such as is observed when any considerable portion of the small intestine has been destroyed. When the opening is high up and implicates the jejunum, the fluids which escape are less offensive than when the opening exists in the lower part of the small intestine. When the opening is in the large bowel, the discharge often consists of hard fæculent masses, and is always of the character of that passed naturally from the rectum. Within also, when the large bowel is implicated, there need be little disturbance of the natural position of the bowel; there need be no angle formed by the upper and lower portions of the bowel fixed at the aperture; and there need be no adhesions of the serous surfaces to secure the wounded intestine to the abdominal wall, as the bowel may have been opened external to the serous sac.

Certain changes will occur in an artificial anus, as time passes. If the opening was originally small in the intestine, the external orifice will gradually contract, the escape of the contents will diminish in proportion to the contraction, and, in some few weeks or months, the aperture may close. If the aperture in the intestine was originally large, the artificial opening will gradually become less, up to a certain point, and then remain stationary in size. The edges will often become thick and callous, and will also occasionally become puckered inwards; at the same time, the fold of membrane which projects from within, becomes gradually directed away from the orifice which leads into the upper portion of the bowel; for the stream of fæculent matter acts constantly against the corresponding surface of this projection, and inclines it towards the orifice of the lower portion, sometimes so as to close it completely, and thus effectually prevents the passage of fæces from the upper into the lower portion of the bowel. In proportion to the extent and projection forwards of this fold, will the passage of fæculent fluid or food across the area of the artificial anus, and through the lower portion of the intestinal canal, be diminished; the fold acts as a dam across the natural passage, and directs the stream through the new aperture, to be discharged externally. And as the facility of communication from one to the other becomes less, so the orifice of the lower portion contracts, while that of the upper portion often becomes dilated and thickened. As the artificial orifice is not guarded by a sphincter-muscle, the escape of the contents is constant, and is beyond the control of all voluntary efforts or desire. The patient's health will become much deteriorated if the small intestine is open far above the ileo-cæcal valve; nutrition is then but imperfectly carried on. The patient suffers greatly from the excoriation caused by the acridity of the dis-

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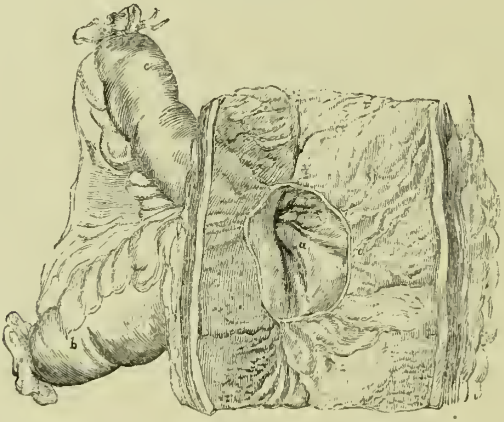
* Lawrence *On Hernia*, p. 380.

Fig. 85.

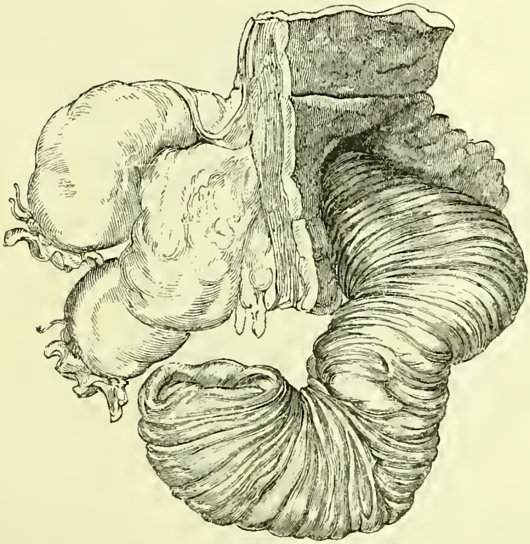


Artificial anus, showing the angle between the two portions of intestine. The lower portion of gut in the drawing is the one nearer the stomach, and is larger than the other. (Museum of Royal College of Surgeons, No. 1,384.)

charge, the constant moisture of the skin, and the frequent necessity to cleanse the wound; so that with a slight attack of diarrhœa, or other exhausting ailment, one in such a condition rapidly sinks. 'The prospect of regaining and preserving health and strength,' observes Sir W. Lawrence, 'when the continuity of the intestine cannot be restored, depends entirely on the situation of the unnatural opening: is greater in proportion as that is nearer to the inferior end of the canal, and smaller as it approximates to the stomach.'

One of the most marked effects of an artificial anus, whenever the fæculent fluids escape entirely through it, is that the lower portion of the bowel, *i.e.* all below the aperture, becomes contracted; and in time, so much so, as hardly to be recognisable as the intestine of an adult. The tube is, however, rarely obliterated. Dupuytren mentions a case which occurred in the Hospital of Val-de-Grâce, in Paris, observed by M. Begin, and in which the lower portion of the bowel was obliterated, and formed a solid cord. The portion of intestine forming the artificial anus was the transverse colon. The patient was eighty years of age when he died, and he had suffered from artificial anus for forty years. The lower portion of the rectum was not

FIG. 86.



Artificial anus with prolapsus. (Museum of Royal College of Surgeons, No. 1,386.)

quite obliterated, but next to the artificial orifice, no trace of canal was to be found.*

In an artificial anus there is a constant tendency towards prolapsus of the bowel (Fig. 86.) There may also occur a hernial protrusion behind or through the wall of the adherent intestine, or between it and the external wound (Fig. 87.) This is not frequent. Prolapsus usually takes place through the orifice of the upper portion, and is a common occurrence to a slight extent. Generally the protruded bowel is readily returned, and can then be retained by gentle pressure secured by a bandage or truss. But prolapsus may be very extensive, and may even prove fatal.

A patient operated on by the author, in the autumn of 1859, for strangulated femoral hernia, was found, when the sac was opened, to have mortification of the greater portion of the circumference of a piece of small intestine. The bowel was cut open where dead, and the protruded intestine left in the wound. An artificial anus was thus established; and though the patient was greatly reduced, and extremely ill for many days subsequently, she recovered sufficiently to quit the hospital about three months after the operation. The artificial anus was then rather more contracted than at first, but almost all the fæces passed externally through the opening. She gradually gained strength, and recovered sufficiently to be able to do a little work. About six months after she left the hospital, one afternoon while lifting some furniture when cleaning her room, she felt something suddenly wrong in the region of the artificial anus, and immediately experienced great pain. She was only able to get on to the bed, and, being quite alone, was unable to procure assistance. She now perceived that there was a large protrusion at the artificial anus. In the evening her husband returned home, but so drunk that he could not be made to understand the urgency of her sufferings, and would not consent to any medical advice being procured. The poor woman passed the night in great suffering, and in the morning the husband, having returned to his senses, called Dr. Martyn of Brompton to see her. Hearing the particulars of her history, Dr. Martyn asked the author to visit her. A large mass of prolapsed bowel, some three feet in length, was found lying external to the artificial opening. The mucous membrane was dark-coloured and almost black from congestion, and blood was oozing from its surface generally. The protruded portion of bowel was thrown into several convolutions, was greatly distended and much solidified, and excessively tender when touched. She was admitted into St. George's Hospital, where, after consultation with Mr. Cutler, the author attempted the reduction of this really frightful-looking mass of prolapsed bowel. While attempts at reduction were being made with extreme care and much gentleness, a quantity of intestine (covered with peritonæum) was observed to escape suddenly from the abdomen, by the side of the bowel already prolapsed and covered with mucous membrane. A double complication now existed. The exact peculiarities of this complication will it is hoped be understood by reference to the accompanying illustration; but, to render the case more clear, its various stages and conditions are shortly recapitulated. Previous to the occurrence of the prolapsus, the original openings in the intestine and the abdominal wall were adherent to each other by their opposed margins, so that one common opening, the artificial anus, was the result; the visceral and parietal peritonæum being continuous with each other around the internal aspect of the opening. Through this common opening a portion of the upper bowel became prolapsed, and projected externally. This projection was the mass covered with mucous membrane, which was seen in the first instance. The pressure exerted by the protrusion of so large a mass of bowel on the margins of the artificial anus, caused the adhesions between the two original wounds to give way; consequently the opening in the wall of the bowel was no longer attached to the abdominal opening; and the latter now communicated directly with the interior of the peritonæum. Through this opening, leading into the cavity of the peritonæum, the portion of bowel covered with peritonæum passed out: but there had already escaped, through the same external opening, the prolapsed bowel. The following condition of parts, therefore, was found at the aperture in the abdominal wall:—

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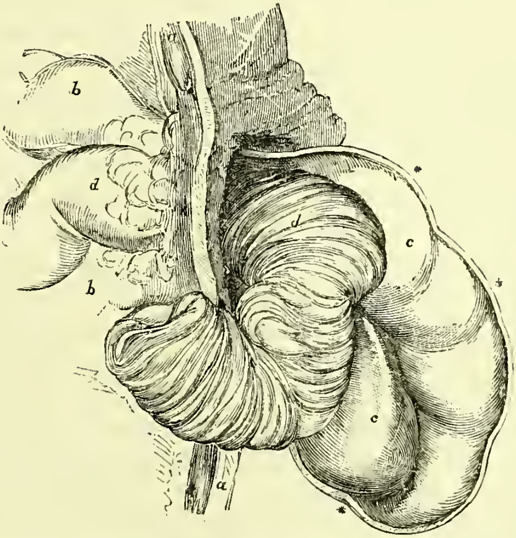
* *Dictionnaire de Méd. et Chir. pratiques,* tom. iii. p. 133.

Fig. 87.



Artificial anus, with prolapsus and hernia (ideal representation.) *a.* The abdominal wall. *b.* The coils of intestine inside the peritoneal cavity, some of which have formed a hernia, and are represented at *c*, external to the abdomen covered with the peritonæum, which is marked by an asterisk. *d.* One of the two coils forming the artificial anus which is prolapsed, and shows its mucous surface external to the abdominal wall.

Several convolutions of bowel protruding externally and without sac. In the walls of one portion of this protruding mass was the opening of the bowel made at the time of the operation for the relief of the hernia: and through this opening projected a large mass of prolapsed bowel; the mucous membrane of which was a dark red colour and highly congested. So that, side by side, exposed to the air and lying outside the abdominal wall, there was intestine protruding covered by peritonæum, and intestine prolapsed covered by mucous membrane: the two being but portions of one mass of small intestine escaped from the peritonæal cavity, through an artificial outlet at the femoral ring.

The prolapsus was readily reduced, by drawing upon the portion of bowel which had last escaped. The latter was traced to the point where the invagination commenced, and was then gently pulled until the invaginated portion was entirely unfolded. The intestine was then easily returned into the abdomen, and the original wound of the bowel secured to the margins of the external opening with sutures. The poor woman was so much exhausted by her prolonged sufferings, that she expired the following morning. The portion of intestine below the wound was found very much contracted, and free from fæculent matter.

When hernial protrusions occur through an artificial anus, the coverings of the hernia will be solely formed by the coats of the adherent intestine, mucous membrane outside, and peritonæum within; but should the hernial protrusion be other than small, we must anticipate some separation of the adhesions which attach the orifice of the bowel to the abdominal wall, as occurred in the case last described. In such a case, the pressure exerted on the intestine round the orifice would be very considerable, and the protruded sac might even be ruptured from this cause.

The treatment of artificial anus depends much on the features of each case. When the opening is small, we need do little more than require the patient to be kept as clean as the circumstances of the case will permit, and meanwhile endeavour to restrain the escape of fæces or food through the orifice, by the application of gentle pressure. Closure of the opening will frequently occur, in such a case, without any further interference on the part of the surgeon. A young woman, operated on for strangulated femoral hernia, by Mr. Johnson in St. George's Hospital, recovered with an artificial anus in the left groin. By degrees the opening gradually contracted; once or twice it appeared closed; again opened; and, some eight months after the operation, became entirely healed. A similar case occurred in the practice of the author, though the artificial aperture closed in a much shorter period.

If the opening shows no tendency to close, and the patient objects to operative interferences, the inconvenience can be but little mitigated by external measures. Pressure offers the best prospect of regulating somewhat the escape of the fæces. Various arrangements have been adopted to alleviate the distress of the patient; receptacles of different shapes and materials have been so fixed to the body, as to cover in the orifice of the bowel and receive its contents as they pass out. But though much ingenuity has been exercised upon the construction and adaptation of such appliances, at best they have been found but of trifling service. Mr. Lawrence recommends the constant use of a truss to prevent prolapsus; and the author's experience induces him strongly to advocate the importance of this recommendation. A compress of linen placed in the opening, with a larger pad over it, and a truss applied over the whole, will in a great measure restrain the contents, as well as prevent the protrusion of the bowel.

The relief or closure of artificial anus has been attempted by surgical interference. Before alluding to the measures adopted for, what is termed, *a radical cure,* we must shortly refer again to the condition of an artificial anus which has baffled the surgeon's attempt to close it by pressure. In such a case, the orifice of the upper portion of the bowel will be well marked, and the fold of mucous membrane (*éperon,* as it is termed by French authors) will be more or less prominent. If a finger can be passed into the opening of the upper portion, and another into that of the lower portion of the bowel, and the ends of the fingers be approximated, they will only be separated at these two points by the opposed walls of the intestine; but for an instrument to pass through from one portion of the intestine to the other, the peritonæum would have to be necessarily twice perforated; for usually no adhesions exist between the serous surfaces corresponding to these points. The éperon, or fold, at its *free* margin, consists of two layers of mucous membrane; but immediately behind the free border, will be formed of the muscular and serous layers of the bowel.

In order to push back the prominent edge of the éperon, Desault passed a tent of linen three inches in length into the intestine, through an artificial anus in a patient under his care, and covered the opening with a compress and bandage. This tent he proposed to remove twice a day, to allow the evacuation of the fæces; but he found that, after some noise and pain in the bowels, some fluid was discharged through the rectum, and during three following days several motions were passed. The tent was discontinued on the eighth day, and the opening was closed by compress, and supported by a truss. The case quickly recovered. It is stated that nothing had passed through the rectum in this case, from the time of the receipt of the wound which produced the artificial anus, until the treatment alluded to was adopted by Desault, a period of four years. This method of treatment can only be recommended for trial in cases in which the internal angle of the bowel is not very acute, and consequently when the éperon is not very prominent. In fact, in such cases, with proper care and simple pressure, time will most probably ensure permanent obliteration of the artificial opening.

It will now be evident that the chief obstacles to the closure of an artificial anus, which defies the usual palliative treatment, arise from the loss of intestinal wall, the consequent acuteness of the angle at which the portions of the intestine meet at the aperture, and the unavoidable prominence of the éperon or fold —conditions which most effectually interfere with the passage of fæces into the lower division of the bowel. If the serous surfaces of the two portions of the intestine, within a few inches of the opening, were adherent to each other, nothing would appear more justifiable or easier than to divide the éperon some distance inwards, commencing at its free margin ; and then this process of treatment would probably be as safe as it would be easy. A direct and free communication between the upper and lower portions of the bowel would be thus immediately established ; the éperon would be destroyed ; and fæces would flow along the natural channel more readily than escape externally, especially if pressure was applied over the opening. But it has been explained that the éperon is formed merely of a duplication of the mesenteric or attached border of the wounded bowel ; the artificial aperture would, in most cases, be situated in some portion of the former free surface. The duplication would therefore consist, within the intestine, of two layers of mucous membrane : within the abdomen, of two layers of serous membrane, and intermediately of the muscular and cellular coats of the bowel. To divide this éperon to a sufficient extent to relieve the obstruction it produces, would necessitate cutting into the cavity of the peritonæum ; for we should have to cut through the serous surfaces of the opposed portions of bowel. Even a further risk would have to be encountered. There might be intestinal convolutions lying between those two surfaces of bowel, which must necessarily be divided in order to secure sufficient increase of space in the canal ; therefore an instrument carried across the space occupied by such convolutions might seriously injure any portion of viscera there interposed.

To Dupuytren* we are indebted for originating a method of treatment which, perhaps of all others, holds out the prospect of dividing the éperon, with as little amount of risk to life as can possibly be obtained in so formidable an undertaking. But the fact must be fully appreciated, that any interference with this éperon, or projecting fold, must always necessarily be attended by considerable risk of peritonitis, and danger to life.

'Restoration is seldom accomplished by the united efforts of nature and art,' writes Dupuytren, 'when the loss extends to four-fifths, or to the entire circumference of the intestine, with or without the mesentery, whatever may be the extent of the mischief in length. The destruction of the bowel, the contraction and change of direction in the tube, the projection of the ridge and septum, are here carried to the greatest extent, and constitute an insuperable obstacle to the transmission of the intestinal contents in their natural course. If compression be employed with sufficient exactness to prevent escape of fæces, symptoms of strangulation are produced, such as colic, nausea, vomiting, hiccup.'

Dupuytren saw that, if, without opening into the cavity of the peritonæum, he could in extreme cases destroy the éperon by any means which would facilitate the passage of fæces in their natural course, the probable result would be the closure of the artificial anus; but that, without the removal of the éperon, there was no prospect of relief. He determined to make the attempt to establish a direct communication between the upper and lower portions of the gut by destroying the septum. After one or two attempts to effect this by pressure and ligature, he ultimately made use of an instrument, which he termed an *entérotome.* By the application of this instrument, he considered that the projecting ridge and septum might be destroyed in a short period. It is here only requisite to state, that this instrument is so constructed that it somewhat resembles a pair of forceps, the blades of which can be separated from each other, or, when adjusted to the septum, can be approximated by the action of a screw, so closely as to be firmly fixed on the part embraced in their grasp. One blade, being grooved, receives the edge of the other, when the instrument is closed; so that any intervening tissue, thus firmly grasped, is so effectually compressed as to be destroyed in a very short time. When it has been decided to use this instrument, 'the first step is to find the two openings of the intestine, and to determine accurately the direction taken by the corresponding portions of the canal. Usually this is the longest and most difficult part of the proceeding. The discharge of the contents generally points out to us, without much trouble, the orifice and course of the upper end. But greater difficulty is experienced in discovering the lower. When the position of the openings and the course of the two portions of bowel have been ascertained, one branch of the entérotome is introduced into one end of the bowel, and, according to circumstances, carried to the depth of one or more inches; the other branch is placed to a corresponding depth in the other end.'* The blades are then adjusted and firmly fixed by the action of the screw. Dupuytren recommended that the pressure should at once be carried to such an extent as to extinguish circulation and life in the part immediately; and, to prevent circulation being re-established at any point, he advised the pressure to be increased every second day.

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* *Mémoires de l'Académie de Médecine,* tom. i. 1828.

The application of the instrument does not usually occasion much pain, according to Dupuytren's statement. The effects of the application will not be completed for seven or eight days; after which the separation of the sloughs, occasioned by the strangulation of the intestinal wall, will allow the instrument to be removed without further trouble, and without the blades being opened. 'By the division and loss of substance, the ridge and the double septum, which separate the two ends of the bowel, are destroyed, so as to re-establish the interrupted communication between them, and restore the natural course of the aliment and fæces.'† This treatment appears simple enough and most rational, when considered merely as a mechanical procedure; but in practice we must not be surprised if its adoption were to prove productive of very severe symptoms in many cases, and even fatal in not a few. In the first instance, when closing the blades of the entérotome, we run the risk of catching between the blades a portion of intestine not implicated in the artificial anus; and if we escape this danger, we have to run great risk of setting up peritonitis, by the action of the instrument on the two surfaces of that membrane enclosed within the blades. Still, on the other hand, it must be remembered that the patient has to submit to a most loathsome condition—great suffering and continual annoyance without any prospect of relief; while in many cases there is also the probability of life being much shortened, from the want of adequate nutrition. The surgeon, in proposing the operation to a patient, can honestly state that it holds out the prospect of permanent benefit, though its performance is attended by considerable risk; but the patient himself should decide whether to submit to it, after having had placed before him all the reasons for and against its adoption.

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* Dupuytren, op. cit.

† Op. cit.

The following are the results which Dupuytren arrived at from his own experience and that of others, in the use of the entérotome:

Of forty-one operations, twenty-one were performed by Dupuytren, and twenty by other surgeons. Three cases terminated fatally; one from supposed fæcal effusion; one from peritonitis excited by the operation. Of the remaining thirty-eight, the greater number had no unpleasant symptoms: some had colic, nausea, and vomiting. Fistulæ, more or less extensive, remained in nine; rendering the constant use of a truss necessary. Twenty-nine patients were completely cured, in periods varying from two to six months.

Some doubts have been expressed by M. Jobert* respecting the correctness of Dupuytren's conclusions regarding the safety of this operation; and the former recommends that, in the use of the instrument, the pressure should, in the first instance be gradual, and only increased as the symptoms permit. He has observed all the symptoms of strangulation follow the application of the blades, when applied so firmly as immediately to destroy the life of the part, and states that fatal cases have occurred after such application.

Surgeons have had but little experience in the application of the entérotome in this country. Fortunately the cases requiring its use are rare in the present day; but if we are permitted to draw a conclusion respecting the advantages of treatment by the use of the entérotome, and the effects produced by its application, we would most strongly advocate a gradual, rather than a rapid closure of the blades in any case in which it was considered advisable to employ the instrument.

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* *Traité des Mal. chir. du Canal intest.*, tom. ii. p. 125.

Foreign Bodies in the Stomach and Intestines.

The introduction, whether accidental or intentional, of foreign bodies into the stomach, is not an uncommon occurrence; their retention in the alimentary canal is generally productive of evil; and therefore the management of such a case is well worthy the utmost consideration of the medical practitioner. The term 'foreign body' is applied to a substance which, when introduced into the stomach or bowels, is proof against the rapidly-dissolving action of the gastric fluid; such a substance as retains its original size and general configuration while stationary within, or while passing through, the intestinal tube.

Great varieties of foreign bodies have been found in the stomach and intestines after death: and though it may not be necessary here to enumerate all, it will be found desirable, practically, to distinguish certain varieties from others, and so to classify them; for according to their character, consistence, or shape, they act more or less prejudicially on the parts which surround them.

The following classification will embrace sufficiently the varieties most frequently met with:—

1. Round and flat bodies, such as money, fruit-stones, bullets, pebbles, calculi, &c. These substances are generally the least dangerous in their effects.

2. Materials which, by accumulation, form large masses; such as hair, string, the husk of the oat, &c. Such substances generally constitute the largest foreign masses met with in the food-tube.

3. Sharp-pointed or cutting bodies; such as pins, fish- or other bones, knives, false teeth, &c. These are generally attended by fatal consequences, if they become lodged in the stomach or intestine.

Foreign bodies may remain in the stomach for a certain period without producing much inconvenience; but generally, when retained, they are attended, sooner or later, by serious, if not fatal consequences. The treatment of a case in which a foreign body has become lodged in the alimentary canal, gastric or intestinal, must therefore be ever a subject of extreme anxiety. If the substance be a piece of money or any other small body, it will be passed, often without much discomfort, in the course of a few days, sometimes within forty-eight hours of having been swallowed. But should the substance be a bone, or other irregular-shaped or uneven mass, it may be some weeks before it escapes through the rectum; and its progress through the tube is often attended by pain, and sometimes much distress and suffering, in passing the external outlet.

The early symptoms, indicative of a foreign body in the stomach, will depend very much on the shape and nature of the mass. If it be a pin, or a fish- or sharp meat-bone, or any steel instrument pointed or uneven, or metallic tooth-plate, the symptoms usually present will be pain referred to the epigastrium—pain sometimes of a very severe character; a sense of weight and discomfort at the stomach; often a desire to vomit, or an actual ejection of the contents of the stomach, and blood, either mixed with the fluid thrown up, or passed in the motions. If the patient is thin and the substance large, it may occasionally be detected through the abdominal wall. When the foreign body is formed by an accumulation of hair or other tissues, introduced into the stomach by degrees from time to time, the symptoms will be chiefly those of severe indigestion, such as a weight and pain in the epigastric region.

The effects of a foreign body passed into the stomach will also differ according to the shape and consistence of the mass. The substance may be slowly propelled into the intestine, and thence escape externally through the natural outlet; or be retained in the intestine, and there produce fatal mischief, or be rejected from the stomach by vomiting. The mass may be retained in the stomach, producing there ulceration and perforation of its coats, and so ultimately fatal peritonitis; or peritonitis may occur as a consequence of partial obstruction, without perforation. The mass rarely remains in the stomach without ultimately producing fatal complications.

The treatment of cases in which foreign bodies have entered the stomach, must depend greatly on the nature of the substances forming these bodies, as well as upon their shape.

A lady in attempting to swallow some pills, dislodged her artificial teeth, consisting of two central incisors fixed to a small gold plate. The mass passed at once into the pharynx and œsophagus; and was soon followed by pain referred to the median line, at a point a little above the epigastrium. On attempting to take food, she experienced difficulty in swallowing it; and the greater portion almost immediately returned. Mr. J. Blackstone attended the patient for some days, but as she did not improve the author was requested to see her. There was still, on the tenth day, much discomfort, inability to swallow without pain, and food could only be taken in a fluid form and in small quantities at a time. These symptoms continued without much alteration till the nineteenth day. As the patient was then no better, but evidently thinner, an œsophagus tube was gently passed down the throat: when approaching the cardiac orifice, the extremity of the instrument came in contact with some resisting, apparently solid, substance. With very slight pressure this appeared to be dislodged, and the tube passed freely on. On its withdrawal the patient expressed herself relieved, and was at once able to swallow with comfort.

In a few days, however, she again began to complain of pain in the region of the pyloric orifice of the stomach: but though the pain persisted without relief, it did not prevent her from partaking of food. In this state she continued till one day she again attempted to swallow some pills, which made her vomit; and she brought up a quantity of fluid from the stomach, and with it the artificial plate and teeth attached; as perfect as the day when swallowed. The mass was fixed nineteen days in the œsophagus; and remained ninety-seven days in the stomach. The longest diameter of the plate was three-quarters of an inch: a sharp point, somewhat hooked projected on one side; a less sharp one on the other: these no doubt occasioned the arrest of the foreign body at the pyloric orifice. The patient had no bad symptom after the ejection of the plate; and perfectly recovered her usual good health.

In another case, which occurred in the practice of Mr. T. Taylor of Edinburgh, an artificial plate with six teeth attached was accidentally swallowed; but as the extremities of the plate were rounded, and free from sharp projecting points, and although the longest diameter of the mass was one and three-quarters of an inch, it was passed per anum, in three days after.

To Dr. Parr of New Brighton, the author is indebted for the notes of the following case. A lady awoke in the middle of the night choking; she thrust her finger into her throat and pushed down some hard substance. After some little investigation she discovered the loss of her artificial teeth; which consisted of four teeth attached to a gold plate with two sharp projecting arms to embrace the adjoining teeth. After the nervous dread consequent upon the knowledge of what her stomach contained, was overcome, she suffered no inconvenience until upwards of two months, when she complained of pain and tenderness in the region of the head of the colon. Six months from the time she swallowed the teeth, they passed by the rectum, bright and clean. The long diameter of the plate was two and a quarter inches, width three-quarters of an inch.

There is nothing more frequently swallowed, and that intentionally, than pieces of money. The swindler in the streets of London, in the habit of passing false coin, when detected in the act, will invariably endeavour to swallow the piece of money intended to have been passed, and will generally succeed in the attempt, even if it be the size of a half-crown. No evil effects occur in such instances. The treatment usually pursued by the man, in his own person, is peculiar and not irrational. He avoids purgative medicine as worse than useless. On the other hand, he has recourse to a constipating diet, and feeds for some days on hard-boiled eggs and cheese, in excess, beyond his usual diet. His theory is, that the more solid and copious the contents of the bowel, the more sure is the piece of money to be caught in the passing fæculent matter, and thus will be most readily propelled onwards to the external outlet. It is believed that aperient medicine delays the expulsion of the coin.

An interesting case is recorded in the annual report on the convict prisons for 1868, of a man, who was suddenly seized with vomiting blood, and died almost immediately; a post-mortem examination revealed a half-crown piece lodged in the œsophagus, which had produced ulceration of the tube and perforation of the aorta.

It is a very common occurrence, that a pin placed in the mouth accidentally slips down the pharynx. Not unfrequently this happens with children; and the mother, in her anxiety to do something, immediately doses the little patient with castor-oil; and *then* seeks medical advice. In such an accident, it is far better to avoid purgatives; and rather allow the patient to eat plentifully, so that the foreign body may have the best chance of being carried through the intestinal canal, imbedded in and surrounded by fæculent matter. It were better to encourage costiveness than establish relaxation of the bowels.

A sharp-pointed mass retained for a time in the stomach or intestine, may gradually penetrate the walls of the canal, and ultimately escape externally, by perforating the walls of the abdomen. Whenever such a result is indicated by pain, and swelling, and redness of the external parts, the escape of the mass may be hastened by a cautious use of the knife. Previous to the escape of the foreign body, adhesions will have connected the stomach or intestines to some portion of the abdominal wall, and thus the internal wound will be shut out of the peritonæal sac, and the foreign body will be contained in a cavity of its own, between the opening in the bowel and that in the abdominal wall; otherwise, the passage of any substance through the walls of the intestine, into the cavity of the peritonæum, would set up violent if not fatal peritonitis; such as we witness when the bowel is suddenly ruptured.

Needles or pins, when once swallowed, may escape from the intestinal tube, travel through various structures, and subsequently make their exit some distance from the point at which they had passed through the coats of the bowel. It has been affirmed that persons have swallowed whole packets of needles, and that at various times, and in different parts of the body, separate needles have made their appearance. But it is necessary to receive with some caution the evidence of a patient under such a supposed condition. The peculiar impulses of an hysterical mind occasionally induce a female to practise an amount of deception towards the medical attendant, which may induce him, on the first view of the case, to take for granted that which, upon careful investigation, would turn out to be fictitious.

The more globular the mass the greater is the chance of its becoming impacted in the intestinal canal, and producing fatal obstruction of the bowels. Such a mass may pass from the stomach into the duodenum, and make some progress downwards; but as the small intestine becomes less in diameter towards the ileo-cæcal valve, so the obstruction to the passage of the foreign body, as it is propelled onwards, increases at every inch of its progress; and if the size or shape be such as to prevent its passage through the lower portion of the small intestine, all the symptoms of complete obstruction soon occur. This form of foreign body sometimes consists of a calculus, escaped from the gall-bladder, through an ulcerated opening communicating with the duodenum. Similar results, *i.e.* obstruction, have been known to occur from the retention of calculi formed by the matting together of the husks of the oat, these particles being introduced into the stomach in that well-known national food of the North called 'oat-cake.' Various specimens of calculi thus formed are to be seen in the Museum of the College of Surgeons.

The stomach has sometimes been found to contain large masses of different substances, which have been swallowed by patients little by little, until the accumulation has become so great as to set up local irritation, disturbance of the digestive functions, and fatal peritonitis. In the 35th volume of the *Med.-Chir. Trans.* p. 65, the following case is recorded: 'Mrs. B., in December 1842, was affected with hæmatemesis, vomiting a washhand-basinful of blood. During the succeeding forty-eight hours she lay in a state of total unconsciousness, the pulse scarcely perceptible. The vomiting did not return, and she slowly recovered.' In the autumn of 1845 she complained of frequent sickness, pain in the epigastrium, and in the left groin. 'A hard tumour was discovered in the left iliac fossa, which moved freely across the abdomen as she moved from side to side. The size and shape of this tumour were very much like an ordinary placenta, and imparted to the fingers the feeling of being very heavy.' Nausea, occasional hæmatemesis, and constipation, were the symptoms most prominent in the progress of this case. In October 1850 the patient died.

'The stomach contained about a pint of semi-fluid matter, and felt very like the crop of a fowl; the duodenum resembled a large sausage stuffed with lead. On cutting into the stomach, it was found partially filled with some gruel-like fluid, and in the lower half were an immense number of pins, of a purple-black colour, not corroded, varied in size, all bent or broken, many very pointed. The pyloric half of the stomach presented a remarkably thickened condition of the villous coat, being highly vascular, and raised in rugous elevations like the stomach of an ox. The weight of the pins contained in the stomach was *nine ounces.* An incision made into the duodenum *displayed a mass of pins very tightly packed, of various shapes, similar to those found in the stomach, and wholly obstructing the tube.* These weighed *a pound,* as nearly as could be ascertained.'

The author was requested by Dr. Blakely Brown to examine the body of a young woman, aged eighteen, who had suffered from pain about a tumour in the epigastric region, and had frequently vomited after meals. She subsequently became sickly; and she appeared childish for her age. After a severe attack of vomiting, and much pain about the tumour, she became collapsed and died.

The cavity of the peritonæum contained several ounces of purulent serum, and the general surface of the intestines afforded evidence of recent peritonitis. On opening the stomach a large mass of hair and string, matted compactly together, was found occupying the greater portion of the cavity, and moulded to the shape of the stomach: a narrowed piece projected into the pyloric end. The hairs were long and black, and were matted together with pieces of string and particles of food. The mass measured when dry six inches in length, three and three quarters in depth, and two and a half across, but was much larger when first removed from the body. Another mass occupied the lower portion of the duodenum and commencement of the jejunum. This portion of the bowel was considerably dilated. This second mass consisted of a smaller quantity of hair than that removed from the stomach, but of a larger proportion of string. The mass was fourteen inches in length, two and a half in depth, and two and a quarter broad in the thickest part. The specimens are contained in the Museum of St. George's Hospital.*

In the fifth volume of the *Transactions of the Pathological Society* is the record of a case by Dr. Bucknill, in which a man, aged twenty-two, subject to epilepsy and maniacal excitement, died from the effects of peritonitis. 'There was found a perforation of the stomach, larger than a shilling, situated at the small curvature of the stomach, with dark-coloured and ragged edges. The peritonæum was in a state of universal inflammation. On opening the stomach, there was found a mass, about four pounds in weight, composed entirely of cocoa-nut fibre, with bits of string, &c. The mucous membrane was healthy, except at the seat of ulceration.'

Mr. Poland has recorded in his *Prize-Essay* the following case: Jas. R., aged twenty-three, a lunatic, confessed to his attendant to having swallowed the handles of two iron spoons. On examination, apparently in the stomach, there was felt a body of the size of a small egg, and upon deeper pressure the sensation of friction between foreign bodies was elicited. The man subsequently appears to have made some vague statements of having repeatedly swallowed spoon-handles, sand, and pebbles. He made little complaint, but stated that he often suffered from severe pain. He vomited occasionally. One day, about three months after his first confession to the attendant, the patient was seized with sudden severe pain in the abdomen, which continued to increase through the night; and from the effects of this attack he died the following morning.

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* For case and drawing see *Pathological Transactions,* 1851-52, p. 327.

The cavity of the abdomen was filled with dark greenish fluid and much recent lymph. The stomach was lying in the left hypochondriac region, in rather a vertical position, and was much contracted. About an inch and a half from the pylorus there was a perforation on the anterior surface of the duodenum of the size of a swan-quill. On laying open the stomach and duodenum, 'a mass of iron spoon-handles and nails and other articles were seen closely packed together.' There were thirty-one entire spoon-handles about five inches long, four half handles, nine nails, half an iron heel of a shoe, one screw, four pebbles, and one button; the weight of the whole mass was 2 lbs. 8 ozs. An entire spoon-handle was found in the duodenum, with the flattened extremity towards the pylorus, opposite the perforation.

Of all the remarkable instances on record of a large number of foreign bodies being swallowed intentionally, there is none to equal in interest one recorded by Dr. Marcet. In this case, a sailor swallowed at different times a number of clasp-knives, some thirty-seven in all. Some of these he passed whole, per anum, at intervals; subsequently he passed some fragments, and once he vomited a knife-handle. A short time before his death a portion of one was felt fixed across the rectum, but gave so much pain on examination that it could not be extracted. He lived ten years after having swallowed the first knife. On examination after death, one blade was found fixed across the rectum, with one extremity projecting into the muscular parietes of the pelvis. A back spring of a knife had transfixed the descending colon opposite the left kidney, and projected into the peritonæal cavity; the spring was four inches and a half long. In the stomach there were between thirty and forty fragments of knives. For the further particulars of this case we must refer the reader to Dr. Marcet's interesting report.*

Foreign bodies which pass into the intestine are apt to be obstructed in their progress at the ileo-cæcal valve. Such is frequently the case with small bones, fruit-stones, &c., and occasionally the mass will here set up ulceration, and be followed by abscess in the right iliac region. The common result of such an abscess is general peritonitis, and the patient often soon sinks under the attack; but less frequently the abscess opens externally, the foreign body escapes, or is removed, and the patient recovers after a severe and prolonged illness. Fruit-stones are apt to become lodged in the appendix, and are a frequent source of mischief. Such stones are sometimes carelessly swallowed with fruit in large numbers, and are occasionally retained in the intestines for many months without inconvenience; but are as often the cause of much irritation and even troublesome obstruction.

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* *Med.-Chir. Trans.* vol. xii. p. 52.

Mr. Clement, of Shrewsbury, operated on a patient suffering from obstruction of the bowels, for the relief of which the ascending colon was opened. The patient was so much relieved by the operation, that at the end of six weeks she was able to walk about. About a week subsequent to this period she was seized with colicky pains, and an obstruction occurred at the bottom of the artificial opening, when suddenly a hard mass was shot out from the artificial anus. This substance 'was found to consist of five plum-stones firmly agglutinated to each other. These were followed by sixteen other single plum-stones, and afterwards by a very copious fæculent evacuation. On the following day three more stones found an exit, accompanied by two small bones.' At different intervals the patient continued to pass plum-stones, the total number collected previous to her death being *one hundred and sixteen.*

Mr. Clement's account of the post-mortem conditions are highly interesting. 'The cæcum and the ascending part of the arch of the colon appeared unusual in size, until it was suddenly cut short at the *transverse* part of the arch by the intervention of the most rigid stricture I ever felt. If a piece of whipcord had been firmly tied round this part of the intestine, the occlusion would not have been more complete than was effected by this organic change. The whole remaining portion of the transverse arch of the colon, its descending part, and sigmoid flexure, were collapsed, and formed a thin flaccid tube.

'The stricture itself was of cartilaginous hardness, and the closure of the canal so complete, that it would not admit of the passage even of a bristle. The extent of the stricture was not quite an inch, of a white pearly appearance, perfectly smooth, and had no more apparent vascularity than a tendon.' * The probability is, that the stricture was the result of effused fibrine, produced by the local irritation, if not ulceration, from the presence of the foreign bodies.

It is still a question open to discussion, and rather to be decided by future experience, how far we may be justified in opening the stomach for the removal of a foreign mass. It must be borne in mind that most of the cases in which a foreign body is retained in the stomach terminate fatally; that life in such cases is limited to a very few years, or perhaps months. The operation of opening the stomach is, on the other hand, a very serious one, perhaps the most serious the surgeon can undertake; but still the cases in which we may contemplate the operation, are so hopeless without surgical interference, that the author is rather inclined to recommend the operation, in such cases as might be considered inevitably fatal if left to themselves. The only recorded successful cases of gastrotomy were those in which the operation was performed on account of the lodgment of a foreign body in the stomach. See the Table in the essay on INJURIES OF THE NECK.

Foreign bodies which penetrate the abdominal wall may pass into the intestinal canal, or remain lodged in the cavity of the peritonæum.

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* *Med.-Chir. Trans.* vol. xxxv. p. 209.

Hennen mentions a case in which a man was struck by a musket-ball, on the evening of the 18th June, at Waterloo. The ball penetrated the abdomen a little below the navel. The principal complaint of the patient, subsequent to the receipt of the wound, was incessant straining to stool; and on the sixth day a bullet, enveloped in mucus, was passed through the rectum. Ten weeks after the receipt of the wound the man passed some bits of cloth by stool. A small fistulous opening continued for a short time in the seat of the original wound, and when this had entirely closed, there was a slight hernial protrusion at the cicatrix.*

Should an elongated body be thrust into the abdomen, it is always desirable to remove it as soon as possible. The difficulties of such a proceeding will, of course, depend as much on the size and shape of the mass as upon its situation; but any difficulties of removal should not weigh with the surgeon; for if the mass be allowed to remain in the abdominal wall or cavity, more serious results are likely to ensue than if it be at once removed. If allowed to remain in the cavity without an effort being made to remove it, mischief of a serious character is sure to be set up within a short time, and repeated attacks of peritonitis, even if relieved for a period, will destroy the patient sooner or later.

The accidental passage of a cedar pencil into the abdomen, through the urethra of a female, is recorded by Mr. Erichsen. In this case the pencil apparently was pushed through 'the posterior wall of the vagina, passed upwards behind the bladder, and then traversed the peritonæal cavity. At this time also the intestine was doubtless perforated, and continued transfixed through two of its coils until the time of extraction, a period of nearly eight months.' Repeated attacks of peritonitis occurred after the accident. The patient became much debilitated, and subject to constant vomiting. From the examination made previous to an operation, the pencil was felt to be lodged on the outer and right side of the bladder, vagina, and rectum. An incision was made through the abdominal wall over the point where the pencil could be detected, and it was removed without difficulty. The surface of the pencil was stained in places by the intestinal contents. The pencil was five inches long, and was cut at one end to a sharp point, which was still perfect. The patient only survived the operation four days.†

If a foreign body can be distinctly felt in the cavity of the abdomen, having penetrated any portion of the walls, the advantages of early removal will consist in getting rid of an irritating mass, in securing a better prospect of arresting peritonitis, and, should the intestine be wounded, in establishing a more certain escape for its contents through the external wound. If the mass be not removed, the repeated attacks of peritonitis will greatly emaciate and reduce the patient, agglutinate the convolutions of intestines together, and very much complicate matters in any future attempt to relieve the patient by operation.

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* Hennen's *Military Surgery*, p. 408.

† *Med.-Chir. Trans.* vol. xxxix. p. 15.

In conclusion, the author would urge the importance of *early action*, when operative interference is indicated or offers a prospect of prolonging life, in all cases in which intestinal obstruction is the cause of threatened danger. He believes that, in many instances, an operation for the relief of obstruction is not successful in consequence of being performed *too late*—that is to say, after peritonitis has commenced. He believes that the wound of the peritonæum, necessary in many operations for the relief of obstruction, is a minor evil; that it is not the operation or its effects that destroy life; but that when a patient suffering from obstruction dies after operation, death is more probably the result of peritonitis produced by the obstruction, than to be attributed to the effects of the knife.

GEORGE POLLOCK.

INJURIES OF THE PELVIS.

THIS essay comprises a description of the contusions of the soft parts covering the pelvis; the fractures and dislocations of the bones composing it; the injuries of the viscera contained within that cavity or connected with it, and the methods to be adopted in their treatment.

The relative situation of the pelvis to the rest of the body, the manner in which it is enveloped by muscles, the great strength of the bones themselves, the peculiar nature of their articulations and bonds of union, and the almost circular figure which results from this construction, are circumstances which concur, individually and collectively, to resist the effects of external violence. However, whilst the bones constitute a means of protection for the contents of the cavity, they sometimes become the secondary agents in the infliction of considerable mischief, for fatal injuries are sometimes produced by their fragments perforating the pelvic viscera.

The arrangement of the subject is as follows:

I. Contusions involving the soft parts in contact with the outside of the pelvis.

II. Fractures and dislocations of the bones forming the pelvis.

III. Injuries of those organs in relation with the pelvis which are connected with the functions,

A, of Micturition;
B, of Generation, male and female;
C, of Defæcation.

I. *Contusion* of the soft parts covering some portion of the pelvic bones is of frequent occurrence. Thus, a railway labourer often receives a squeeze between the buffers of two railway carriages. The result is more or less bruising of the soft tissues, and the laceration of smaller or larger blood-vessels, which, in some instances, gives rise to a large extravasation of blood. I have seen nearly the whole of the integuments detached from the external surface of the glutei muscles and fascia, without any sign of a scratch on the skin. Blood had been effused into this pouch, and a large swelling was the result. Around the swelling ecchymosis appeared a few days after the infliction of the injury. After repose and the local application of stimulating lotions, the blood became absorbed. Large swellings, the result of the effusion of blood, occasionally arise after kicks from a man or beast, the soft parts being well placed, between the iron boot-toe or shoe and the dorsum of the ilium, to receive the full influence of such force. In these injuries, the blood is extravasated beneath the gluteal fascia, and forms a circumscribed swelling, over which the fluctuation of its fluid contents is distinctly perceptible. Ecchymosis does not appear around the swelling, even after the lapse of several days from the receipt of the injury. Under these circumstances the collection of blood might be mistaken for an abscess, if the history of the case be not carefully ascertained. The nature of the swelling may be diagnosticated, however, by learning that it appeared soon after the receipt of a blow; that no pain, before the kick was received, preceded its formation; and that its development had not been attended with any constitutional disturbance.

Contusions of an apparently trifling nature, at first sight, may yet be attended with appalling results. Thus, a delicate, strumous, badly-nourished boy receives a blow on the pelvic region, as a kick, whilst at play, the primary effects being merely a local tenderness or stiffness. But in a few days intense constitutional disturbance may arise, and death ensue from disease of the membranes of the spinal cord.

II. Dislocations and Fractures of the Bones forming the Pelvis.

Injuries of the pelvic bones and joints are usually severe. They are attended with more or less risk to life, which does not ensue solely from the damage done to the bones themselves, but arises from the contents of the region being involved in the mischief.

It would be idle to write a systematic description of the dislocations and fractures of each pelvic bone separately, since fracture and dislocation occur so frequently in combination, and as the effect of the same amount of violence inflicted on the patient. Indeed, as the pelvic bones are united together by interarticular fibro-cartilage, as well as ligaments, a solution of continuity between their articulating surfaces differs widely from the displacement of the articular extremities of the long bones which compose diarthrodial joints. Hence it happens that very great violence is required to sever the union between the pelvic bones, and the same degree of force may produce a solution of continuity of the osseous texture in preference. Even in those cases in which the greatest amount of dislocation is effected, as, for example, of the os innominatum from the sacrum, the borders or edges of the articular surfaces of either one bone or the other, or even of both bones, are frequently broken off. This fact, incontestably demonstrated by preparations in every anatomical museum, renders it extremely difficult to decide during life whether the case be one of fracture simply or a combination of the two injuries. The only movable articulation, to be noticed in this essay, in which articular cartilage and a synovial capsule exist, is that between the sacrum and coccyx; and to a description of the dislocation of the latter bone a few lines will be devoted.

The massive strength of the pelvic bones of the adult skeleton and the capability of resisting violence enjoyed by the tissues which unite them together, combine to neutralise the effects of the application of ordinary force, which in bones constituted with less strength would give rise to a solution of continuity in the osseous texture. Extensive fractures are, however, occasionally repaired. There is a pelvis in the Museum of the Royal College of Surgeons demonstrating this fact (No. 2,915^{A}). The effect of a moderate degree of direct violence, is to break off the more salient parts of the bones. Thus, a man receives a kick upon the ilium from another person, or from a horse, by which a fragment is broken off from its crest. The anterior superior spinous process of the ilium is not unfrequently separated from the crest of the bone in this manner. But in children the passage of a heavy body over the pelvic region often produces fracture. A preparation in the Museum of the Royal College of Surgeons (No. 488, Catal. vol. ii. p. 59) shows that nearly the whole extent of the os pubis may perish and become separated. The sufferer was a girl five years old, and her recovery was complete.

The greatest amount of injury, however, is inflicted by heavy crushing weights passing over the pelvis, or by falls from great heights on to very hard substances. By such violence the bones may not only be broken and disjointed, but the important organs

Fig. 88.

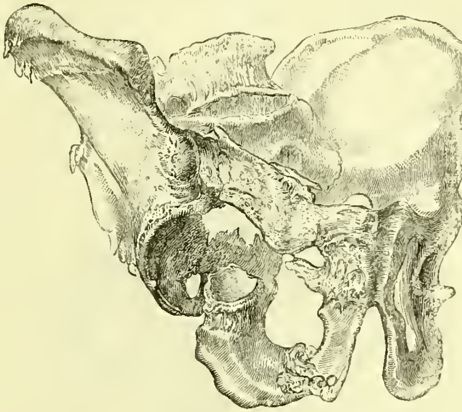
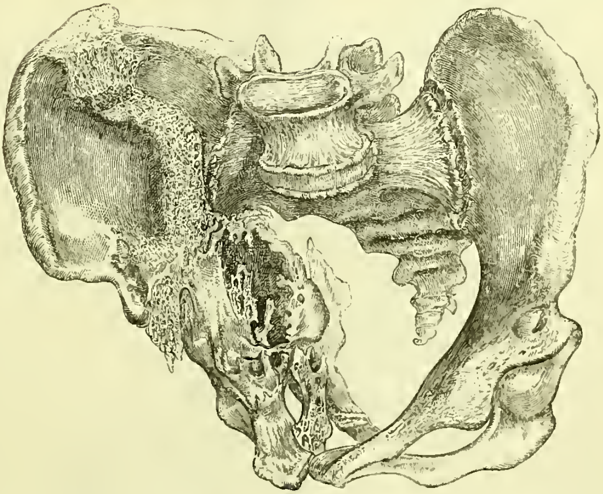


Fig. 89.



Views of a preparation (No. 2,915^{A}) in the Museum of the Royal College of Surgeons. A pelvis, the right side of which has been extensively fractured in several places and the fragments reunited; from a man aged sixty-one, who fell from a height upon some stones, August 12, 1845. After recovering from the effects of the fracture, and being able to limp about with the aid of a stick, the right leg shorter than the left, he was seized on December 3, with symptoms of typhus fever, and died December 8. See *British American Journal of the Medical Sciences*, September 1849. Also *Ranking's Abstract*, vol. x. p. 171. (Presented by Sir George Duncan Gibb, Bart., M.D., Feb. 1868.)

within the region may also be injured by fragments of bone perforating their tissues.

The diagnosis of simple fractures of the pelvic bones is usually unattended with difficulty. Unless there be much contusion, or a large extravasation of blood over the injured bone, the crepitus, arising from the movable fragment rubbing against the fixed bone, is easily felt.

Fig. 90.

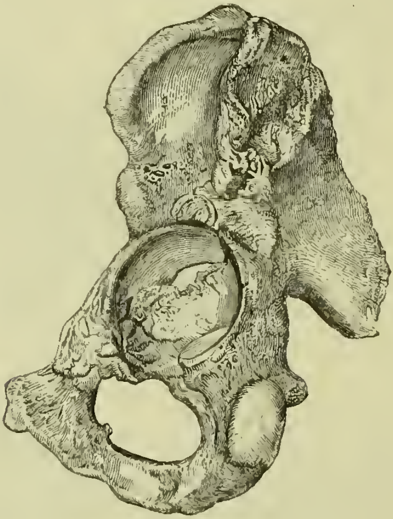
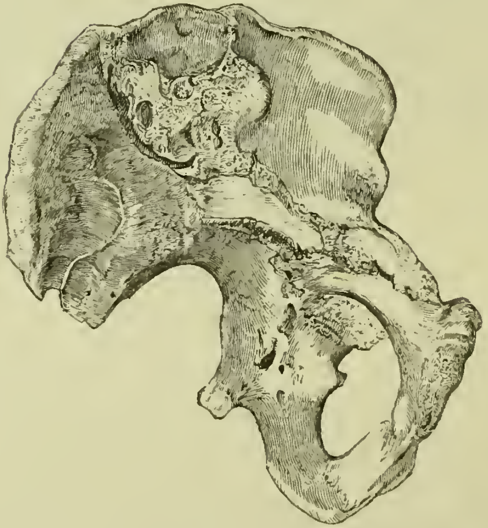


Fig. 91.



Two views of the fracture of the pelvis referred to on the opposite page (Museum Royal College of Surgeons, No. 2,915).

The treatment consists in enjoining absolute rest, and the application of a bandage in such a manner as to prevent the movement of the piece of bone which has been broken off.

The os innominatum may be broken into fragments by the head of the femur being violently driven against the acetabulum.

A few cases of this injury are recorded. One is related by Sir Astley Cooper in the first part of his *Surgical Essays*, page 51, and Plate II., fig. 6. A preparation in the Museum of the Royal College of Surgeons beautifully illustrates the nature of this injury, and the reparation which may take place. (Figs. 90 and 91.) The details of the case are recorded by Mr. Earle, in the nineteenth volume of the *Medico-Chirurgical Transactions.* It appears from the preparation, that the lines of fracture diverging from the acetabulum have followed the track of the union of the three separate portions of which the fœtal bone was composed.

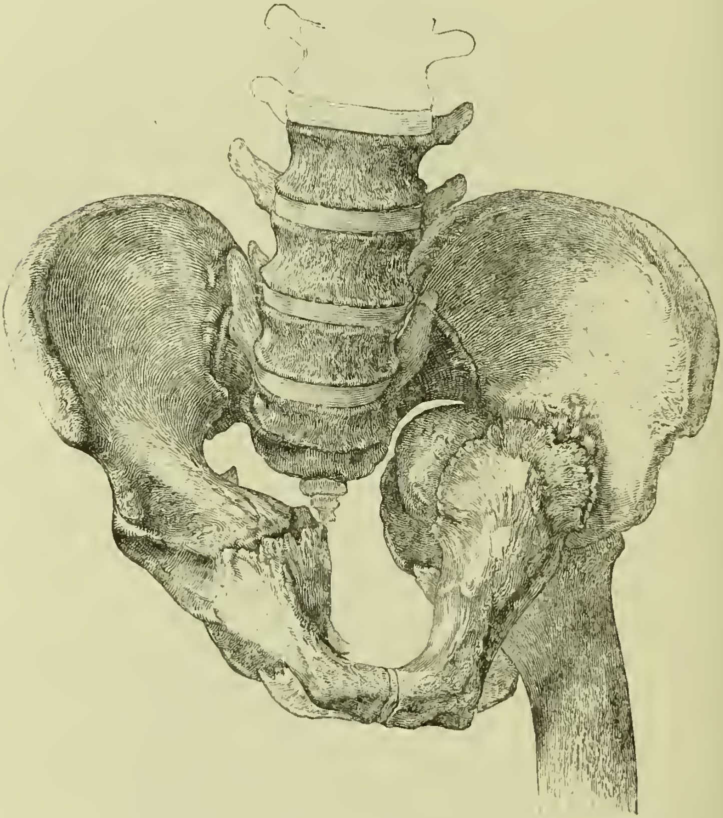
Mr. Moore has given the history of a case of repaired fracture of the pelvis from this cause in the *Medico-Chirurgical Transactions*, vol. xxxiv. p. 107. The case is of such great interest, that one of the woodcuts illustrating that paper is here introduced, by permission of the Council of the Society. (Fig. 92).

Injuries of this kind may be mistaken for dislocations of the head of the femur, or fracture of its neck. They are usually accompanied with more or less deformity about the hip, and pain on any movement of the hip-joint. The sensation of crepitus, when the lower extremity is moved, seems to be diagnostic, however, of the nature of the injury.

Portions of the brim or border of the acetabulum are occasionally chipped off. In this injury the deformity which results simulates that of dislocation of the head of the femur; for partial displacement of the head of that bone sometimes accompanies the injury. The departure from the normal outline of the region, with the existence of the crepitus of fracture, will assist to establish the diagnosis.

In a paper by Mr. Benjamin Travers, which was read before the Medico-Chirurgical Society in 1854, he has given an account of two cases which he assumes to be illustrative of the fact of a fissure or crack passing through the acetabulum, without displacement, or any other primary sign of the nature of the injury which can be relied upon. The very acute pain produced *by pressure upon the projecting spine of the os pubis*, and the inability of the patient to maintain the erect posture immediately after the infliction of a blow or fall which produces the mischief, he considers diagnostic of the injury. There is little or no swelling, and the limb may be cautiously handled, and gently rotated, without producing much complaint on the part of the patient, being recumbent, which posture he is forced to observe for many weeks. At first the limbs are of equal length; but when the patient recovers, the injured limb is found to be permanently shortened. Mr. Travers believes there is reason to suppose,

FIG. 92.



Old injury of the pelvis—the head of the femur driven through the acetabulum. From *Med.-Chir. Trans.* vol xxxiv.

that in these accidents certain changes occur, secondarily, in the head of the femur, that it undergoes a change in shape, the articular cartilage is absorbed, and eburnation ensues. The subject certainly requires further investigation; and this short allusion to it is introduced in the hope that it may lead to more extended inquiries.*

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* See also *Further Observations in Surgery*, by B. Travers, 8vo. London, 1860.

The coccyx can be broken, or dislocated from its articulation with the sacrum, by the application of direct force. The injury may be produced by a kick or a fall on to any projecting hard body. It is stated that this bone is sometimes broken in the effort of parturition.

Great pain at the end of the sacrum and in the immediate region of the injured part, increased by the act of walking, or in the performance of defæcation, induces the injured person to seek relief. If the bone be broken, the sensation of crepitus would be sufficient to indicate the injury. If, upon passing the finger into the rectum, and when feeling the anterior surface of the lower extremity of the sacrum, an unusual projection be felt, with mobility of the coccyx and no crepitus, it would indicate that, probably, the coccyx was dislocated either forwards or backwards. The one variety could be distinguished from the other by ascertaining which of the two bones formed the prominence on the anterior aspect of the sacrum. If the projection is formed by the base of the coccyx, this bone would be dislocated forwards. But if the end of the sacrum produces the prominence, the coccyx must have been displaced backwards.

In the treatment of fracture, absolute rest is required. The reduction of the dislocation may be effected by pressure. With the index-finger introduced into the rectum, whilst the patient is under the influence of chloroform, the bone may possibly be brought into its normal relations with the sacrum; after which perfect rest must be enjoined.

III. (A.) INJURIES OF THE ORGANS OF MICTURITION.

A. *Injuries of the urinary bladder.*—A solution of continuity of the tissues of the bladder may be caused

1. By direct violence,
    - a. *Without* fracture of the pelvis; produced by the passage of a wheel over the hypogastric region, by kicks, falls, and perhaps by violent contraction of the abdominal muscles.
    - b. *With* fracture of the pelvic bones, the fragments of which have not injured the bladder; produced by the same causes as before stated.

2. By foreign bodies penetrating its walls,
    - *a.* Through the abdominal parietes; produced by projectiles from fire-arms, bayonet or sword thrusts, and other cutting instruments, as a trocar in paracentesis abdominis, or in paracentesis of the viscus itself for relief of retention of urine.
    - *b.* From the rectum; produced by bougies, stakes of wood or iron, a trocar, &c.
    - *c.* Introduced along the urethra; produced by knives, sounds, catheters, or lithotrites.
    - *d.* From the vagina, during instrumental parturition.
    - *e.* By fragments of broken pelvic bones.
3. By accumulation of urinary secretion,
    - *a.* In the fœtus; in consequence of imperforate urethra.
    - *b.* In the adult; in consequence of an impediment to the passage of the urine along the urethra.

1. *Ruptured or burst urinary bladder.*—The tissues composing the urinary bladder may be torn or lacerated by external violence, without the abdominal walls showing any signs of the mischief. This injury may be inflicted when they are in a perfectly healthy condition; but the details of the cases prove that it only occurs when the bladder is distended with urine. Under ordinary circumstances, the anterior walls of the pelvis and the strong recti muscles protect this viscus from the effects of direct violence; but when it is distended with secretion, and the tension of the abdominal muscles is relaxed under the influence of inebriation, that part of the bladder which is in relation with the urachus, the anterior abdominal walls, and the peritoneal membrane, becomes unusually exposed and liable to be torn.

Morbid anatomy teaches that the rent may pursue a vertical, transverse, or oblique course. In the majority of instances, the aperture has been found to extend from the attachment of the urachus through the posterior wall of the organ, involving not only the proper tissues of the viscus, but its peritoneal covering as well. Under these circumstances, this great serous sac is wounded, and the urine escapes from the bladder into the cavity of the peritonæum. In some rare examples, the anterior wall of the bladder only has been torn, and the urine then becomes extravasated into the connective tissue of the pelvis.

The records of above fifty examples of this injury show that, with the exception of three, all the cases terminated fatally. Of the three cases which recovered from the injury, in one only the symptoms were those of extravasation of urine into the peritonæum;[*] in another the extravasation was into the pelvic connective tissue, and this was complicated with fracture of the pelvis;[†] and the third was of the same nature, but without that complication.[‡]

In the majority of cases, the injury was produced by direct violence, such as a kick above the pubes, the passage of a cart-wheel over the hypogastric region, or the fall of an antagonist on to the same part. The injured person was generally drunk, the bladder distended, and the signs of the injury in nearly all cases were immediately manifested. In rare instances, patients have passed a few hours after the accident in comparative freedom from urgent symptoms, but they were men who were drunk at the time, and probably too anæsthetically intoxicated to be conscious of their condition. In a very few cases, the bladder was torn without any evidence of direct local violence. But these patients are said to have fallen upon their backs from a height, or down a flight of stairs.

The immediate and prominent symptoms of this injury are, intense pain in the abdomen, rapidly followed by collapse, and urgent desire to pass urine, with repeated but ineffectual attempts to void any. The patient sometimes dies at this stage. But if reaction takes place, all the well-known symptoms of peritonitis rapidly supervene, and a fatal result is sure to ensue, if this disease be not arrested. The variety of peritonitis may, or may not be of the most sthenic kind; that is, after death plastic effusions are not always to be found uniting the abdominal viscera together, or forming large masses of lymph. But that kind of peritonitis is developed which is commonly associated with the most fatal results. An abundant sero-purulent effusion exists, of an unorganisable character, which bathes the abdominal viscera; and, in a few cases, it appears that fluid such as that above described has been drawn off by the catheter when introduced along the urethra and through the rent in the bladder. After the first urgent symptoms have passed off, the case becomes one of local peritonitis, and the usual train of phenomena characterising that malady appear in succession;

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[*] Mr. Chaldecott's patient; *Prov. Med. and Surg. Journal*, 1846, p. 333.

[†] Porter's patient; the case related by F. Rhynd, *Path. and Prac. Observations on Strictures*, &c. 8vo. 1849, p. 48.

[‡] Mr. Syme's patient; *Contributions to the Path. and Prac. of Surgery*, 8vo. 1848, p. 332. Possibly Dr. Thorp's case should be added to those of recovery; see page 721.

the only indications of the injury, in addition to those of peritonitis, being the immediate effects referable to the viscus injured. Thus, the sufferer continues to evince a constant desire to micturate, and a few drops occasionally pass from the urethra, as the result of his efforts. Most commonly, however, not a drop is voided. Urgent tenesmus is another most distressing symptom, and by the repeated straining, but ineffectual attempts to defæcate, a little urine may be expelled. From this continued desire to empty the bladder, and failure in voiding urine, the surgeon is induced to pass a catheter. As no impediment to the introduction of the instrument exists, and as perhaps but an ounce or two of urine flows through the tube, the catheter is pushed further into the pelvis, and, without doubt, as some of the recorded cases demonstrate, through the laceration in the posterior wall of the bladder into the peritoneal cavity. The result has been to draw off a very large quantity of fluid, in one instance, 'between five and six pints;' a quantity of urine which it is difficult to believe a ruptured bladder could contain. Yet the fluid is stated to have appeared clear and normal. In some cases, the fluid drawn off by the catheter has had a little blood mixed with it, just enough to give it a slight tinge of red.

This injury must be treated like peritonitis. Suitable treatment should be adopted to prevent dilatation of the bladder by an accumulation of urine, the necessity for the patien voiding it, and to guard against the possibility of repeated escape of the secretion through the laceration into the peritonæum. The case can only be regarded in this light from the first moment of the accident. For that the extravasation of urine into the peritonæum must excite inflammation of the serous membrane, can never be for a moment doubted. Post-mortem examination of the cases sufficiently attests the fact. The primary effects in the immediate neighbourhood of the injured viscus are seen in the firm union of the serous surfaces, and in effusions of plastic lymph which completely shut off the pelvic region from the larger portion of the great peritoneal sac. All treatment must be subservient to that which is capable of arresting or controlling peritonitis. None can, therefore, so much conduce to the salvation of life, as that which effectually limits the primary influence of the irritating fluid to the pelvic region. The plan of treatment commonly adopted in cases of acute peritonitis must therefore be rigidly carried out in this injury.

Upon opium, and its effects upon the constitution, our chief reliance must be placed. The patient should be brought under the influence of opium as quickly as possible. A full dose of tinctura opii or liquor opii sedativus, in a little camphor-julep, must be administered, and repeated at short intervals, if the abdominal pain continues. As soon as the pain subsides, the quantity of opium may be diminished, but if the pain increases, more opium is required. Food of every kind should be withheld for twenty-four or even forty-eight hours after the infliction of the injury, and then only just sufficient to sustain life allowed. A safe guide to the supply of food is indicated by the wants of the sufferer, and unless the desire for nourishment is expressed, it is better to withhold it until the necessity is pointed out by nature. Small pieces of ice placed in the mouth, to allay the distressing thirst, may be permitted to the patient *ad libitum*. The external surface of the body must be kept as warm as possible, and every measure adopted to promote cutaneous perspiration. The abstraction of blood by means of leeches applied over the region of the injury, may in some cases be desirable, but usually the attendant prostration scarcely admits of their employment. Cutaneous local counter-irritation is beneficial, and warmth and moisture applied over the abdomen favour the functions of the skin.

The conservation of the urinary bladder in a state of complete contraction and repose is one most essential step towards the healing of the wound in its walls. The surgeon should remember that the secretion of urine would be lessened, and the quantity, perhaps, become very small indeed, as generally occurs in collapse and peritonitis. Very little necessity, therefore, exists for the repeated introduction of instruments, in order to empty the bladder, during the first twenty-four, or even forty-eight hours, after the injury. A perusal of the recorded cases of this injury will not fail to impress the reader with the apparent want of caution displayed in the introduction of catheters beyond the neck of the bladder, also of the danger which must accrue when a metallic catheter is pushed far into the cavity of the organ, because so small a quantity of urine passes through it when it is really in the bladder and only there. Will an anatomist believe that a ruptured bladder can contain ‘between five and six pints’ of urine, or a physiologist that this quantity would be secreted in about forty hours, whilst the patient was suffering from peritonitis, the result of extravasation of urine into the peritoneal cavity? The inference, with the majority of readers, would be, that the catheter had passed through the rent in the viscus, and removed the serous effusion together with the extravasated urine from the peritonæum. The chief point, therefore, with the surgeon must be to maintain the contracted state of the bladder, because in this condition the edges of the rent remain in close approximation. And for another reason too. In a hollow viscus, constructed as the urinary bladder, the mucous membrane holds a somewhat variable position to the other tissues of which the organ is composed. The loose attachments of this membrane admit of a variation in its relations to that tissue with which it is in immediate connection, during the opposite conditions of extreme distension and contraction. So that when all the coats are torn through, in a line perfectly corresponding at the moment of extreme repletion, the non-contractile mucous coat might overlie the aperture in the other tunics, when the viscus is empty, and thus form a plug or valve to assist in preventing the further escape of urine through the laceration. And furthermore, the rent would assume very different proportions or dimensions in a dilated and contracted state of the organ.

In order, therefore, to guard the patient against any injury which may arise from the catheter being pushed through the lacerated opening in the bladder, a large flexible instrument should be used, which has an opening at the extreme point, and not at the sides near the end, as the catheter in ordinary use has. The flow of half an ounce of urine, or even less, through such an instrument is sufficient to satisfy the operator that the bladder contains no more. The surgeon must satisfy himself upon physiological principles regarding the quantity of urine drawn off, and not calculate upon a very abundant secretion. Should the catheter be secured in the urethra? If its point could be fixed just within the orifice of the bladder, the urine as secreted would drop from the open end, and all danger of its entering the peritoneal cavity would be thus avoided. But if there be any risk of introducing it too far, or of leaving it even in the rent, it is clear that the repeated introduction of the instrument is preferable. A reply to this query must then, I think, be submitted to the judgment of the surgeon. The patient must not, on any account, be allowed to make a voluntary effort to micturate; and the use of the catheter should be persisted in for *not less* than fourteen days after the receipt of the injury.

It should be here stated that many surgeons doubt the possibility of recovery after rupture of the bladder and its peritoneal covering, that is to say, after extravasation of urine into the peritoneal cavity. Readers interested in this subject may refer to the controversy between Dr. Eben Watson * and Dr. Gillespie † on Mr. Chaldecott's case. A paper on this injury by Dr. Harrison ‡ is of great interest. Recently, Dr. Thorp § has published a case 'in which the peritoneal sac was washed out with tepid water injected through the rent in the organ' ending in recovery! It is to be much regretted that only the local symptoms of the injury are fully detailed. We vainly search in the account of the first two days after the injury for those constitutional symptoms of extravasation of urine into the peritonæum which are so constantly present after that occurrence. This omission is most unfortunate, after the introductory observations which precede the recital of the case.

The urinary bladder has been ruptured by the same local cause as produced a fracture of the pelvis. This result has happened *without* the fragments of the bones inflicting the injury to the viscus. An instance of this injury is related by Mr. Partridge, in the *Pathological Transactions*, vol. v. p. 194. The consequences of these injuries are usually so severe that the prognosis is most unfavourable. The treatment of the case will not differ from that before described.

2. Foreign bodies may inflict injuries on the urinary bladder, after penetration of the abdominal walls; from the neighbouring canals; or from the excretory canal, the urethra; and, lastly, fragments of the pelvic bones may lacerate or penetrate its walls.

Penetrating wounds of the abdominal walls produced by projectiles from fire-arms, bayonet and sword thrusts, nails, spikes, the horns of animals, or surgical instruments, may extend into the urinary bladder. Bullets have lodged in this viscus, and remained in its cavity sufficiently long to become covered with deposits from the urine. Some interesting cases are related by Mr. Guthrie,[*] to which, and to the essays on GUN-SHOT WOUNDS and on INJURIES OF THE ABDOMEN, we must refer the reader.

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* *Edinburgh Monthly Journal*, 1848; the vol. for 1849; and the *Glasgow Medical Journal*, 1859.

† *Edinburgh Monthly Journal*, 1859.

‡ *Dublin Journal of Medical Science*, 1836, vol. ix. p. 349.

§ *Dublin Quarterly Journal*, 1863, p. 306.

Iron or wooden stakes which have entered at or near the anus, after penetrating the walls of the rectum, may perforate the urinary bladder. Injuries of this kind are on record.

A very singular case is recorded by Mr. Prescott Hewett, in which the rectum and urinary bladder were transfixed by the patient falling upon the broken leg of a chair. Death resulted in this case from peritonitis, arising from extravasation of urine into the peritoneal cavity.[†] But a case has been described to me by my friend Mr. Buée, of Slough, in which recovery took place. A man forty-six years old, whilst at play with a companion, was pushed off a cartload of fagots, and fell on to a pointed stake which had been driven into the earth. This, passing through the anus, transfixed the walls of the rectum, and tore the posterior region of the bladder immediately behind the prostate gland. The index-finger was passed into the bladder through the wound. The man complained of intense pain. He was bled, and a full dose of opium administered. Mustard cataplasms and fomentations were applied over the abdomen. He was kept in bed, and in two months after the injury the urine was voided by the urethra.

Sounds, catheters, and lithotrites, if employed without due care, may be thrust through the walls of the bladder. Perforations may be made in the bladder with catheters, under the impression that the patient is suffering from retention of urine, whilst effusion into the abdomen is the real cause of the malady.

M. Velpeau states, that he has known this accident to occur at one of the large hospitals in Paris. The patient was sounded, and no urine came away: they pushed with greater force, and a very large quantity of serous fluid escaped. This was a case of ascites, and the instrument had penetrated the peritonæum. M. Velpeau, adds, 'I was sent for three times in 1832 to urgent cases, and I then saw how very easy it would have been to have made the mistake. One of the patients had not passed any urine for four days, and had his hypogastrium very much distended. I found the bladder empty. He died the same day, in consequence of an intestinal rupture, from external violence, which caused the effusion.'[‡]

In the use of instruments during parturition, direct injury may be inflicted on the bladder; or secondary mischief may arise by violent contusion of the part, causing extensive sloughing. And if care be not observed to ascertain whether the bladder is distended, the passage of the child's head in labour may cause it to burst. The treatment, however, of the consequences of such injuries, will be described in another essay (SURGICAL DISEASES OF WOMEN).

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[*] *Commentaries on the Surgery of the War*, 5th edit. 1853, pp. 572 et seq; also *Med-Chir. Trans.* vol. xxxiii. pp. 197, 198.

[†] *Trans. of the Path. Soc. of London*, vol. i. p. 152.

[‡] Velpeau, *Traité complet d'Anat. chir. gén. et topograph. du Corps humain.*

Cases are on record, and have occurred in my own experience, in which fragments of the pelvic bones, the result of fracture, have penetrated this viscus, causing a fatal issue from extravasation of urine.

3. The urinary bladder is sometimes ruptured by an accumulation of secretion. Cases of this kind are, however, very rare. The injury occurs in fœtal life and in the adult.

Mr. Wilkinson King has published the report of a case of fœtus in which the bladder was burst by accumulated urinary secretion. It happened in consequence of the urethra being congenitally impervious.* Also, cases bearing on this subject are related by Dr. Robert Lee.† In the Museum of the Royal College of Surgeons, there is a preparation (No. 1,967) of 'the bladder of a woman which burst near the entrance of the ureter, in consequence of neglected retention of urine.' See DISEASES OF THE URINARY ORGANS.

Dislocation of portions of the urinary bladder forming hernial tumours in the scrotum, is noticed in the essay on DISEASES OF THE URINARY ORGANS. A remarkable case is recorded in the *Pathological Transactions*, vol. iv. p. 187, illustrated by woodcuts.

Foreign bodies in the bladder.—The following remarks apply to foreign bodies introduced into the bladder along the urethra.

Portions of catheters and bougies, metallic or flexible ; pieces of straw, of tobacco-pipe, pen-holders, hair-pins, a piece of French chalk, of slate-pencil, a bodkin-case ;—these are all articles which have been removed from the bladder or urethra.

If the foreign body remains long in the bladder, it generally becomes coated with deposits from the urine.

In 1829 a sailor was in Guy's Hospital, under the care of Mr. B. B. Cooper. Three months before, a portion of a bougie which he was using broke off, and remained in the bladder. After many ineffectual attempts to remove it with the forceps had been made, Mr. Cooper performed the usual lateral operation of lithotomy. The piece of bougie, coated with phosphates, was removed.

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* *Guy's Hospital Reports*, vol. ii. 1837, p. 508.

† *Med.-Chir. Trans.* vol. xix. pp. 238 et seq.

The man, however, subsequently sank from disease of the kidneys. The case is related in *Guy's Hospital Reports*, 1844, p. 176, and the piece of bougie is in the hospital museum.

Catheters made of gutta-percha become by age and use rather brittle.

A man was admitted into Guy's Hospital under my care, who, after having used an instrument of this material for some time, broke off a piece of the end as he was removing it from the bladder. He soon felt inconvenience from it; and on examination it was easily felt with a sound, as well as some concretion which had been deposited on it. I introduced a lithotrite, and succeeded in breaking the tube in pieces. The fragments were voided with the urine by the ordinary act of micturition, and the patient was entirely relieved of his difficulty.

An elderly man, who had been in the habit of introducing a silver catheter and retaining it for some time, when in bed, fell asleep, and rolling over, broke the instrument. About half was withdrawn, leaving the remainder partly in the bladder and partly in the urethra. I introduced a long pair of forceps by the urethra, and fixing the catheter by pressure in the perinæum, was able to grasp the tube and extract it. Fortunately the broken end of the metal was rather rough and slightly bent at the site of fracture, which afforded a good hold for the forceps.

Mr. H. Norris sent to Sir Astley Cooper a number of calculi formed upon a piece of straw. The patient from whom they were removed had been in the habit of introducing a tube of this material to empty his bladder.*

In the Museum of Guy's Hospital there is the section of a large calculus, the nucleus of which consists of a portion of tobacco-pipe. Sir Astley Cooper used to relate a case in which the nucleus was a silver toothpick.†

A man entered Guy's Hospital, under my care, who had passed the wooden handle of a magnum-bonum steel-pen into his urethra and bladder, with the view to stir up some sediment which he believed to be therein. Many attempts were made with differently-shaped forceps to extract it. None of them held it sufficiently firmly to allow it to be pulled from under the pubic arch. Its end was distinctly felt through the walls of the urethra in front of the scrotum. It was necessary to open this canal at that point, and then it was easily removed.

Incised wounds of the urethra and corpus spongiosum urethræ heal very quickly, and experience has shown that the removal of bodies impacted in the urethra is accomplished with less injury to the canal by external incision than by subjecting the patient to the risk of lacerating the tissues by the use of forceps, and the pressure exerted by the foreign body to be removed.

The direction of all incisions should be parallel with the long axis of the urethra; the opening in the integuments should be larger than in the corpus spongiosum, and that in the last structure longer than in the sub-mucous tissues and mucous membrane. The edges of the wound are on no account to be brought together with sutures, but it should be allowed to heal by granulation. There is no necessity for the introduction of a catheter.

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* A relation of the case, and a drawing of the stones, is given in the *Guy's Hospital Reports*, 1840, p. 241.

† *Guy's Hospital Reports*, 1837, p. 273.

An application was made to the late Mr. Avery to remove from a man's urethra, a two-pronged wire hair-pin, such as ladies employ to arrange their hair. The patient had introduced it with the bent end foremost, and when he let go of the pointed ends they sprang sideways, and became impacted in the walls of the urethra at some distance from its orifice. Mr. Avery introduced a metallic tube into the urethra, pressed the points of the pin together, and conducted them into the tube, where they became fixed; both the tube and pin were then easily withdrawn.

But the strangest thing to introduce into this canal was a piece of French chalk, scraped to a convenient size and shape. At its middle, one end of a piece of string was tied, and to the other end of the string the half of a common shoe-horn. The man actually came into Guy's Hospital with this dangling from his penis. Mr. Thomas Callaway removed the chalk.

Women occasionally introduce foreign bodies into the bladder. The comparative shortness of the urethra enables the surgeon to remove them with greater facility than in the male sex. The operation may be accomplished after dilatation of the canal, when attempts made before have failed.* Mr. Steel removed from the bladder of a girl a bone bodkin-case, with a piece of thread tied around its middle.†

Foreign bodies occasionally pass from the urethra, the entrance of which into the canal is not always explicable.

An interesting case of this kind was one in which the substance seemed to be a fish-bone, which was voided by a patient who was under the observation of Mr. B. Cooper. It is recorded in *Guy's Hospital Reports*, 1841, p. 189. Mr. Alfred Roberts, of Sydney, sent to Guy's Hospital Museum a piece of slate-pencil which had been removed from the bladder, and which, as that gentleman states, is proved to have entered the bladder from a neighbouring viscus.

The presence of a foreign body in the bladder having been detected, it must be removed. In the female this may be accomplished by dilating the meatus, and making use of forceps especially adapted to seize and retain the body. It may perhaps be broken with a lithotrite. In the male the length of the urethra precludes the hope of extracting a foreign body from the bladder by means of forceps introduced along the canal; but it may be crushed with a lithotrite, and the fragments afterwards expelled. If this cannot be done, an incision may be made in the centre of the perinæum, the urethra opened, and the extraneous body removed by dilating the prostatic portion of the canal; or the usual operation of opening the bladder, as in the lateral operation for lithotomy, can be performed.

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* See *Med.-Chir. Transactions*, vols. viii. and xii.; two papers by Sir Astley Cooper.

† *Guy's Hospital Reports*, 1853, p. 316.

Injuries of the urethra.—1. *Simple incised wounds of the urethra* readily heal when longitudinal. Such wounds are dangerous in proportion to their depth, as regards their direction, and the tissues which may be implicated in the injury.

A man, fifty-two years old, was admitted into Guy's Hospital, under my care, in 1855, who had fallen upon a chisel a few days before admission. This instrument had inflicted a wound at the back part of the scrotum, and cut into the urethra. When admitted, the tissues of the scrotum, penis, perinæum, and hypogastric region of the abdomen, were infiltrated with urine, and the integuments gangrenous in several points. Free incisions were made into the connective tissue of the regions involved in the disease; but, in spite of the liberal administration of stimuli and opium, he became delirious, and died within a fortnight after the receipt of the injury. The rule in all like cases is to prevent the infiltration of the tissues with urine; and therefore there can be no objection to enlarge the external wound, if there be the slightest reason to fear that this secretion may become extravasated. The man whose case is related above died from the effects of extravasation of urine, namely, gangrene; and had he sooner applied for relief, it is quite possible he might have lived.

Contused and lacerated wounds of the urethra.—Injuries incidental to the female urethra are rare. It is so short and so well protected by the surrounding parts, that contusions which would cause laceration of this canal in the male, generally produce their influence on the vagina or a part of the vulva. It is liable to injury in the treatment of difficult parturition, the effects of which are shown in the existence of fistulous communications between this canal and the vagina. The treatment of such cases is described in another part of this work (Surgical Diseases of Women).

But the urethra of the male is often lacerated, at any age, especially in boyhood or youth. The injury is produced by violently striking the perinæum in falling astride a firm resisting body, such as the top rail of an iron or wooden fence, the back of a chair, the sharp edge or corner of a box, or of any hard body, in fact, which just fits the 'crutch' or perineal region. The urethra is unfortunately so placed as to receive the full violence of such a blow. For, between the pubic arch above and the resisting body below, it is violently driven against the former, and becomes torn transversely. It may even be completely severed. In this case the continuity of the mucous membrane is destroyed, and if the surrounding parts be much detached from their fascial connections, the two torn extremities of the urethra lie widely apart from one another. The portion of the canal most frequently torn in this manner is that which is placed in relation to the deep perineal fascia, and the rent may be anterior or posterior to this structure. The greatest risk to life attends the last variety; for if extravasation of urine takes place into the connective tissue of the pelvis, the danger of intrapelvic suppuration and peritonitis is imminent.

The simplest form of injury to the urethra very often happens to boys, who in climbing over railings fall astride the topmost bar. A little blood flows from the urethra, as the immediate result of the injury; and, after the lapse of a few hours, the scrotum becomes ecchymosed and swollen. The urine voided by the efforts of the patient soon after the receipt of the injury is often bloodless, or but slightly tinged with blood. Its contact with the abraded surface gives pain, and, in consequence, the child is averse to repeat the effort. In course of time, however, he is impelled by an urgent desire to empty the bladder. Such attempts being fruitless, a surgeon is called, and his assistance is required to relieve the bladder of its contents. The retention of urine is caused partly by the effusion of blood into the cells of the corpus spongiosum urethræ and surrounding tissues, and partly by inflammatory effusion in the immediate neighbourhood of the wounded mucous membrane. Great caution, care, and gentleness are required in the introduction of an instrument. It should be, at first, a flexible catheter without the stilette. Failing to introduce this, the stilette may be inserted; and if the obstacle be still insuperable, a metallic catheter must be employed. The introduction of the instrument is sometimes facilitated by gently pressing the point against the superior wall of the urethra. A catheter should not be secured in the bladder, for when this is done, the urine may ooze along the canal, by the sides of the instrument, and become extravasated into the tissues about the site of the laceration. Besides, the presence of the instrument stretches the urethra, and tends to keep the divided tissues apart. Warm fomentations or evaporating lotions should be applied to the contused regions. If there be continued hæmorrhage, the local application of ice is indicated.

The following case is a good illustration of the symptoms, the treatment, and its happy results, of a contused wound of the urethra. A man thirty-eight years old fell astride the back of a chair, and very soon afterwards passed blood from the urethra. Five hours after the receipt of the injury he was admitted into Guy's Hospital. The bladder was distended, blood flowed from the urethra, and he was suffering much from local pain. I introduced a *large* flexible catheter, through which the urine flowed freely without blood. This was secured to the penis, and allowed to remain in the bladder the three succeeding days. The catheter was then withdrawn, as the urine could not pass through it; but I was unable to introduce another. The instruments seemed to run behind the prostate gland. As the man could not void urine, I incised the perinæum along the line of the raphé. This region contained much extravasated blood, and the urine flowed freely from the wound. Everything proceeded satisfactorily until the sixth day after the operation, when profuse hæmorrhage occurred. It was arrested by applying cold and pressure. At the end of a month after the injury the perineal wound was entirely closed, and all the urine voided by the urethra. When he left the hospital there was no contraction of the urethra, for I could pass a large metallic sound without causing any pain.

The most extensive injury to the urethra and surrounding parts may exist without there being any indications in the perineal region for some time after the accident.

A young man was brought into the hospital who had fallen astride one of the large hooks which connect railway carriages. A few hours after the accident the perinæum showed no signs of injury, and a little blood only passed per urethram. He desired to micturate; made an attempt to empty the bladder, but failed to pass a drop of urine. I introduced a flexible catheter without difficulty, and drew off an ordinary amount of urine tinged with blood. I withdrew the catheter, surmising that no impediment would subsequently arise to prevent the introduction of an instrument. However, greatly to my disappointment, the next time micturition was desired, the patient was unable to pass a drop of urine, and a catheter could not be introduced into the bladder. During the interval which had now elapsed since the introduction of the catheter, the integuments of the perinæum and scrotum had become ecchymosed, swollen, and painful on pressure. An incision was made through the integuments along the whole extent of the raphé, and the severity of the injury was at once detected by gentle examination with the finger. The tissues, covered by the integuments, were extensively torn, the prostate gland could be felt; but as a very large quantity of extravasated blood filled the perinæum, the wound of the urethra was not discoverable. Soon after the perinæum had been incised the urine escaped at the wound, suppuration was established, and cicatrisation proceeded favourably. The man was able to pass water from the urethra in a very good stream. After a time, however, the cicatrix of the urethra contracted, and a phosphatic calculus formed in the bladder. This was extracted by the lateral operation; the wound healed favourably, and the man passed water in a very good stream when I last saw him. In this case, it is not probable that the urethra was completely divided transversely.

The following case is one of complete transverse division of the urethra in the perinæum. A boy, fourteen years old, was brought into Guy's Hospital in January 1856. The penis, scrotum, perinæum, and hypogastric region were black with effused blood. Retention of urine had existed many hours, and the distended bladder could be felt, as high as the umbilicus. This injury had been produced by a fall astride a rail. There was not even a scratch on the integuments anywhere. Of course, an attempt was made to pass a catheter, but it could not be introduced into the bladder. I therefore made an incision along the line of the raphé, and the urine soon began to trickle away; but I was unable to discover the vesical end of the urethra. All the urine passed through the perineal wound for some weeks, but, by degrees, through the whole length of the urethra. Only a few drops escaped by a fistulous opening in the perinæum. After unsuccessful attempts to close this, I divided the perinæum and urethra upon a grooved staff, and introduced a flexible catheter, in the hope that the urethra might be established by healing over it. In this I was disappointed; and the boy left the hospital with the urethra contracted, and the urine passing out of the perineal fistula. He next entered another metropolitan hospital, where the surgeon, by the performance of an operation similar to that above described, succeeded in closing the fistula, re-establishing the urethra and keeping it pervious, so long as instruments were daily employed to prevent contraction. The boy left the hospital, neglected to pass the bougie, and the urethra contracted. He then suffered from retention of urine; a No. 1 catheter was passed, and by increasing the size of the instrument the urethra was dilated. Urinary abscesses subsequently formed in the perinæum, fistulæ were established, and to cure these the perinæum was divided as before. This wound never entirely closed; he was again admitted into Guy's Hospital, suffering with stricture and perineal fistulæ, and left it only slightly relieved. In April 1869, he again came under my care. The last few months he had passed in great distress. There was a small fistula in the perinæum, through which he voided all the urine. I could not pass an instrument along the urethra beyond the perinæum. The canal was quite closed. From the perineal fistula a probe readily passed into the bladder. That viscus was inflamed, and his constitutional powers were very low. I divided the perinæum in the middle line, and established a free communication with the anterior division of the urethra. In due time this operation was attended with complete success, and the man, now twenty-seven years old, left the hospital passing urine easily through the whole length of the urethra, but with a perineal fistula.

The danger to life resulting from extravasation of urine into the pelvic connective tissue, as a consequence of rupture of the urethra and laceration of the surrounding textures, is illustrated by the following case. It also demonstrates the ill effects arising from delay in cutting open the perinæum, as well as from plugging the part with sponge to arrest hæmorrhage.

A healthy man, thirty-eight years old, fell astride a chest, and struck his perinæum against one of its corners with great violence. He came soon after to the hospital, and my dresser passed a flexible catheter without any difficulty, and fastened it to the penis. The next day, the scrotum, perinæum, and penis were infiltrated with blood, and quite black. The urine was passed freely through the catheter. The following day the catheter became filled with coagula, and blood passed along the urethra by its sides. It was removed forty-eight hours after the infliction of the injury, and as the urine did not flow away, I incised the perinæum along the raphé. The coagulum was large, and the hæmorrhage profuse. The urethra was severely torn, and the finger could be passed deeply as far as the prostate gland and by its sides. A catheter could not be introduced into the bladder. The hæmorrhage was arrested by the local application of cold, and a piece of sponge placed in the wound. The next day evidences of local peritonitis appeared, pain in the hypogastric region, shivering, small wiry pulse, and at last hiccough. Opium was freely administered; but the constitutional disturbance increased, the wound became gangrenous, and the man expired upon the eighth day after the receipt of the injury. The decomposition of the body was far advanced when the post-mortem examination was made, and no well-marked indications of peritonitis or of pelvic suppuration were discernible. Death was, however, certainly due to the severe constitutional excitement caused by the injury and its consequences; and if sufficient local evidence of the fact was wanting, its absence must be attributed to the condition of the body at the time the necropsy was made. Doubtless the man died from constitutional disturbance, caused by the extravasation of urine into the pelvic subperitoneal connective tissue; and as regards the treatment of the case, the question is, whether it would not have been better to have incised the perinæum sooner after the injury. In cases of this nature it is impossible to judge of the extent of the mischief in all of them, and as in this instance the catheter was in the bladder, and the urine flowed freely through it for thirty-six hours, I did not consider the operation of incising the perinæum demanded immediately after admission. In all probability the extravasation of urine was extending, in consequence of the fluid escaping by the sides of the catheter; and as the coagulum was quite superficial, just beneath the integuments, the urine infiltrated the deeper-seated tissues, and passed behind the deep perineal fascia, which was lacerated. I should not again make use of a sponge and plug to restrain the bleeding, unless a catheter could be retained in the bladder; for I think it partly assisted in preventing the escape of the urine with the freedom so desirable in these cases. Local pressure with the finger is the best means to arrest hæmorrhage from this region.

The local treatment in all cases of injury to the urethra, in which there is reason to fear that extravasation of urine may take place, is now clearly established. It consists in making an incision along the raphé of the perinæum, so as to allow the fluid to escape with the utmost facility. Delay in the performance of this operation causes imminent risk to the life of the patient, and probably an aggravation of the local mischief.

I have, on one occasion only, used a suture to retain the divided ends of the urethra in contact. The treatment was attended with the most successful results. A very healthy boy, fourteen years old, was kicked on the perinæum by a horse. He came into Guy's Hospital with retention of urine. The perineal region was filled with blood, and I was unable to pass a catheter. I divided the perinæum in its middle line, and after clearing away the coagula saw the divided ends of the urethra. The orifice of the posterior division of the canal was hanging freely in the wound, having been detached from the corpora cavernosa. With a single suture, I brought the ends of the urethra together, passed a gum elastic catheter into the bladder, and fixed it there. The wound healed rapidly; not the least contraction has followed the cicatrisation, although it is now three years since the accident happened.

The constitutional treatment consists in supporting the powers of the patient, and in administering opium if there be much local tenderness, especially in the hypogastric region. Should symptoms of peritonitis arise, the treatment suitable to arrest that malady must be adopted.

Injuries of the urethra, inflicted from its mucous surface, frequently result from the passage of foreign bodies along this canal. In this category must be classed the lacerations of the urethra and its surrounding textures, by the forced introduction of sounds and catheters, in an effort made to reach the urinary bladder. The necessity for this operation arises in consequence of a contraction in some part of the calibre of the excretory tube. When, therefore, the urethra is wounded in front of the stricture by catheterism, the direction of the wound is from its orifice on the glans penis towards the urinary bladder. An opening more or less valvular is made, and extravasation of urine does not commonly take place. The course of the wound, or 'false passage' as it is termed, varies much in length and in its relations to the surrounding parts. If the floor of the urethra be perforated a little behind the bulb of the corpus spongiosum urethræ, the wound may run behind the prostate gland, and then penetrate the neck of the bladder. If the point escapes through the roof of the urethra, it may run behind the pubes and enter the anterior wall of the bladder. If it escapes from the urethra in front of the stricture, it may pass by it on one side or the other, and entering the canal again posterior to the constriction, a twofold perforation of its walls will be established. In these cases extravasation of urine will be almost certain to ensue. Many of the cases of retention of urine admitted into the hospitals require the operation of puncture of the bladder from the rectum, in consequence of the existence of false passages resulting from unskilful attempts made to pass an instrument through the contracted urethra. Even fatal hæmorrhage may ensue from a wound of the urethra thus made.

A surgeon has often to treat these injuries. They are seen at two stages: the first, soon after the false passage has been made, when the patient is suffering from retention of urine, and the bladder in a state of extreme distension filling up the pelvis. What is to be done? Opium in full doses has been administered; the patient has been placed in a warm bath, perhaps chloroform has been inhaled; two or three, or even more, surgeons have failed in their efforts to introduce a catheter; not a drop of urine has escaped from the urethra, but only some blood. Upon inquiry, we find the patient has been the subject of stricture for many years, and that for some weeks the urine has only dribbled away, and at times but a few drops could be voided. To delay emptying the distended bladder is now no longer admissible, and the cries and entreaties of the patient to be relieved compel immediate proceedings. One more attempt is made to introduce a catheter into the bladder, and although different sizes are selected, and the utmost dexterity employed, still the point of the instrument will run into the false passage, and, with the index-finger in the rectum, it may be felt near the prostate gland. By depressing the shaft of the catheter, and with a little force, at the same time directing the instrument with the index-finger in the rectum, it may be made to enter the bladder. The urine flows freely, and the sufferer is at once relieved. But is the relief permanent? The bladder is empty truly, but a false passage is established, by which the urine subsequently escapes into the connective tissue between the organs of the pelvis; and the case becomes one of extravasation of urine. The condition of the patient is not, therefore, improved by this operation.

Another operation by which the distended bladder may be emptied, is that of making an incision in the centre of the perinæum, and opening the urethra from that region behind the stricture. This has been successfully performed in several cases.

Two other operations are practicable. 1st, to introduce a trocar and canula from above the pubes into the bladder; 2nd, with the same instruments to puncture the bladder from the rectum. I have no hesitation in strongly recommending the last operation; and this recommendation is founded upon the observation of a very large number of most successful cases. By this procedure, extravasation of urine will be prevented. The details of the operation would be out of place here.

The second stage is that of extravasation of urine. The escape of this fluid does not always depend upon the catheter being pushed into the bladder, but may arise in consequence of the urethra bursting posterior to the constriction. This last condition generally depends upon a morbid state of the canal in that region, set up by the continued pressure of the retained fluid, by which the tissues are inflamed, and at last ulcerate or slough.

The treatment of cases of extravasation of urine need not be fully detailed here, especially as we have already dwelt upon this point when describing lacerations of the urethra causing the same lamentable consequences.

A curious injury of the mucous membrane and submucous connective tissue of the urethra occasionally takes place during the occurrence of a chordee. The patient feels something snap about two or three inches within the canal, a few drops of blood escape, and considerable tenderness or soreness is experienced during the act of micturition for a few days afterwards. The mucous membrane has been torn. The result is cicatrisation; and as the cicatrix contracts, a hard wiry ring remains, which occasionally establishes a stricture. This may subsequently require treatment by dilatation or incision.

When the urethra is lacerated in the prostatic portion of its course, the blood which flows from the wound passes backwards into the bladder, coagulates, and distends the organ. Great suffering results; constant desire exists to empty the viscus, and ineffectual attempts are made. The distended bladder may be easily felt in the pubic region, and although a catheter is passed, the size of the distension of the bladder is not diminished. Perhaps a few drops of blood and urine flow through the instrument, and that is all. Under these circumstances the viscus may be emptied by fixing a syringe to the end of a metallic catheter, which should be first introduced into the bladder. It is always advisable to make use of a larger instrument than that with which the injury was inflicted. To make the junction of the catheter with the syringe impermeable to air, some warmed white- or bees-wax should be pressed around them at that point. Elevation of the piston slowly and steadily will then remove all the coagulated blood from the bladder. To aid the operation, a little water at the temperature of the urine may be injected.

FOREIGN BODIES IN THE URETHRA.

The reader is referred, on this head, to the essay on CALCULUS.

(B.) INJURIES OF THE ORGANS OF GENERATION.

Injuries of the penis.—Contusions and wounds of this organ are uncommon. In contusions, the effused blood extends freely in the loose subcutaneous connective tissue, and produces an unusually dark purple hue in the part. If blood be effused into the cells of the cavernous bodies, it produces a remarkable induration at the seat of injury, and, when general, permanent priapism for many days.

Incised and lacerated wounds of the integuments only differ from those of other parts in consequence of the loose attachment of those textures to the fibrous covering of the corpora cavernosa. When the wounds are large, their edges become widely separated, so much so in some cases as to lead to the belief that part of the integument is entirely removed.

There is scarcely any region of the body in which the edges of wounds require to be so carefully adjusted as in this. Sutures are indispensable to their treatment. Whether the wound be incised or lacerated, the edges must be maintained in contact with either metallic wire or silk sutures, and dry or wet lint should be gently rolled round the part to support it.

As the result of a contusion of the glans penis, I have seen that part of the organ become gangrenous.

A man, seventy-nine years old, said that he struck the glans penis in a fall. It became sore, inflamed, and subsequently gangrene attacked it. It sloughed off, the wound soon healed, and he passed water as well as ever.

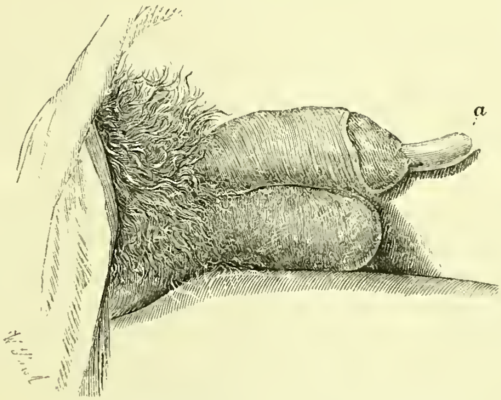
Incised wounds of the prepuce require ligatures. This fold of integument is sometimes injured in coition, and the result is more or less inflammation, giving rise to paraphimosis. The frænum præputii may be torn by the same act. Hæmorrhage to a considerable extent occurs, but it is easily controlled by cold or pressure.

An injury, by no means very rare, is inflicted by children who tie thread or string around the root of the penis. Becoming frightened, and unable to remove the ligature, they delay to speak of it, and the result is, at first congestion, afterwards inflammation, and at last ulceration at the site of the ligature.

The removal of the offending cause suffices to place the parts in a condition to heal quickly, with the application of water-dressing.

The following singular deformity, which forms the subject of the woodcut, was seen in Guy's Hospital in 1867. The man was admitted under the care of Mr. Hilton for another complaint. The details are from notes taken by Mr. Eastes, then Surgical Registrar. W. D., aged 50, nineteen years ago, whilst grooming a stallion, was knocked down by the animal, knelt upon, and bitten on the thigh. The horse taking hold with his teeth of the trousers and penis of the man, lifted him sufficiently from the ground to enable him to clutch the manger and thereby escape. On examination of the penis he saw something projecting from the urethra, just as now represented. There was no wound on the penis, but a little blood flowed from the end of the protrusion and from the ordinary passage by its side. He was confined to the house for four weeks. The woodcut shows a cylindrical body (a) projecting from the urethra. It was pinkish, soft and about $\frac{1}{3}$rd of an inch in diameter and $1\frac{1}{4}$ inch long. Its end was rounded, and at the point there was a small white cicatrix. The corpus spongiosum urethræ terminated abruptly at about 1 inch behind the glans penis. The explanation of the appearance seems to be this. The corpus spongiosum was divided behind the glans penis, and being torn away from its attachments to the corpus cavernosum, became everted at the meatus. Micturition was performed without impediment, the urine being voided by the side of the protrusion.

FIG. 93.



Results of old laceration of the corpus spongiosum.

Injuries of the prostate gland.—The prostate gland is so deeply seated in the pelvis, that it is not liable to injury except by penetrating wounds. Incised wounds of the prostate usually heal very quickly. Such are those made in the operation of lithotomy. The most common injury to which this gland is liable arises from laceration either of one of its lateral lobes, or of its posterior and central part, by the forcible perforation of its tissues with sounds and catheters. This injury can scarcely be regarded as of rare occurrence, judging from the number of specimens accumulated in the museums of London. The growth connected with this gland, and denominated the 'middle lobe,' is frequently so situated at the orifice of the urethra as to offer an impediment, not only to the flow of the urine, but to the introduction of an instrument from the urethra. This contingency should be always remembered when any obstruction is met with at the moment the catheter reaches the orifice of the bladder. The perforation of this lobe is readily effected with a metallic instrument; it may, with care, be avoided, by the employment of a flexible catheter and stilette in most cases. When the end of the instrument impinges on the obstruction, it should be withdrawn from the urethra about half an inch; then, by fixing the catheter with one hand, drawing the stilette out of it for about an inch with the other, and depressing both hands, or gently pressing the catheter onwards by itself, it glides over the third lobe and enters the bladder.

The indications of perforated prostate may not be immediate. But, after the lapse of an hour or two, the patient experiences an urgent desire to empty the bladder. He repeatedly attempts to do so, but in vain. Perhaps a few drops of blood escape from the urethra. Becoming alarmed, he sends for a surgeon, who finds the pubic region occupied by a hard mass, which is very painful when pressed. The surgeon again introduces a catheter, but no urine escapes. By dint of pressure above the pubes a few drops of urine mixed with blood are expressed, then a long coagulum, again a little more blood and urine, and next a coagulum, and so on until the mass in the pelvis is somewhat reduced in size. But still there it remains, and, as an accompaniment, the urgent desire of the patient to empty his bladder. Together with these local circumstances, the constitutional disturbance hourly increases; mental excitability for a few hours is associated, at a later period, with great restlessness. Nausea, and intolerance of solid food, with a clammy white tongue, changes after a time to vomiting, continued retching, and the attendant distress. The clamminess of the mouth passes into a state of parched dryness, and the thirst is most distressing. The tongue becomes dry, brown, crisp and rough on its surface. The pulse, at first full, rapid, and incompressible, by degrees becomes small and wiry, maintaining its rapidity, although, perhaps, not regularly. Respiration is at first accelerated, and lastly hurried. The skin is covered with perspiration, which in the later stages becomes cold, and the face assumes a congested, livid aspect, not unlike that seen in cases of peritonitis.

The first thought which suggests itself to the patient as well as the surgeon, will be to relieve the distended bladder. How is this to be effected? The introduction of the catheter gives no relief, and even the passage of the instrument through the injured prostate might tend to re-open the wound. However this may be, I consider the best plan is to introduce a large metallic or flexible catheter; and then, by applying at its end a syringe, as before described, the blood may be abstracted. The bladder may be irrigated with tepid water, and the operation repeated if necessary. Cold water injected into the rectum may arrest any further bleeding.

The powers of the patient must be well supported, and sedatives or opiates administered to obtain repose.

I have never met with any injury of the vesiculæ seminales.

Injuries of the scrotum and testicles.—The scrotum is often contused, and the effect of the laceration of small vessels ramifying in its textures is shown by effusion of blood taking place in the loose connective tissue of the organ. This causes it to swell and become of a black hue. The treatment of a case of this nature demands perfect rest, with care and arrangement to prevent the part remaining pendent whilst the patient is in bed. A small pillow or sand-bag should be placed between the thighs. The most suitable application is a slightly stimulating and evaporating lotion, which may be composed of liq. ammon. acetatis, spirit. tenuior, and distilled water, in suitable proportions. Lint wetted with this fluid should be placed over the injured part.

Incised and lacerated wounds of the scrotum are produced by falling upon sharp substances, or astride of rails, hooks, &c. The wound is sometimes sufficiently large to permit the escape of one or even both testicles without their undergoing any injury. This extrusion of the testes partly depends upon the contraction of the fibres of the dartos, which corrugates the scrotum, and causes it to shrink to such a degree, that it might appear as if a considerable portion of the structure had been carried away as the result of the injury. Such not being the case, means must be employed to relax the contractile fibres of the dartos. Warmth and moisture will accomplish this. The region should be enveloped in lint wetted with hot water; and when the integuments of the scrotum are sufficiently relaxed, the edges of the wound should be drawn together over the testicles by means of sutures. Either the interrupted or uninterrupted suture may be employed, and the material of the suture be silk or metal, according to the inclination of the surgeon. Adhesive plaster is detrimental. Dry lint should be laid over the part, if the case be one of an incised wound; moist lint, if the scrotum has been contused as well as torn and lacerated. Cold lotions are then to be applied in order to maintain the contractility of the dartos; for if the integuments are allowed to become relaxed and pendulous, suppuration takes place, and the pus collects in the most depending part. Repose and posture are points of too great importance to be neglected in the treatment of these injuries.

Injuries of the testis, epididymis, and vas deferens.—The testicles may be seriously injured by pressure and contusion. The former injury frequently occurs in frays and broils by the forcible grasp of the hand of an antagonist; the latter, by suddenly coming in contact with some resisting body, as when astride a rail or saddle on a horse's back, or by a blow from a swiftly moving body, as a cricket-ball. The constitutional effects of these injuries are in some cases immediate. Prostration, syncope, nausea rapidly followed by vomiting, and intense pain ensue, and some hours elapse before the suffering subsides. The pain is not confined to the organ injured, but extends in the track of the spermatic cord to the inguinal, abdominal, and lumbar regions, in which last it sometimes becomes most severe. After the first effects have subsided, a hydrocele of the tunica vaginalis may be the sequel.

Absolute repose, the local abstraction of blood, the application of warmth and moisture, the support of the injured organ upon a pillow, are the local means to be adopted to prevent inflammation arising. This effect of the injury, however, frequently follows, and in the adoption of suitable constitutional and local remedies to arrest its progress, the usual precautions in regard to the diathesis and powers of the patient must be employed.

Wounds of the testicle are uncommon. A punctured wound may be inflicted by the careless use of a trocar in the performance of paracentesis scroti for hydrocele. The effect produced is more or less tenderness and swelling of the organ, and occasionally the extravasation of blood into the tunica vaginalis. If an operator has reason to conclude that the testis has been thus punctured, it would be well to enjoin rest and apply cold lotions. By neglecting all precautions he might become involved in difficulty.

Incised wounds of this organ are very rare. They cannot easily occur without the serous cavity of the tunica vaginalis being opened, and the surgeon should remember this in the adjustment of the edges of the wound. All serous surfaces being so active in pouring out adhesive lymph, the surfaces of the tunica vaginalis testis and reflexa would soon unite together when brought in contact; and thus the wound of the integuments would be all that remained to cicatrise.

Complete section of the spermatic cord with a sharp instrument should be treated with the hope that union of the divided structures may occur. The divided artery would require twisting, but the ends of the vas deferens might be adjusted by a suture placed through the surrounding connective tissue in such a manner as to keep them in close contact.

Rupture of the vas deferens.—Injuries of the excretory duct of the testis, or vas deferens, are not noticed by surgical authors. Mr. Hilton has favoured me with the history of three cases, in which he believes this duct was torn completely across.

Case 1. A gentleman, between nineteen and twenty years old, was skating, and, in attempting to cut a particular figure, in which act he swung himself round with great effort, he suddenly slipped, so that his right leg was violently abducted. At the same moment he felt something give way in his right groin, accompanied with great pain. The right testis had not been the seat of direct injury, yet it began to swell almost immediately, and in a few hours blood passed from the urethra. Perfectly clear urine flowed away through a catheter, introduced into the bladder, without any blood. This was an indication that the blood had entered the urethra, and that it did not come from the bladder or kidneys. The blood seemed to be arterial, but it was in small quantity. There was continued tenderness and pain near the right inguinal ring, and swelling of the right testis. Leeches were applied over the lower part of the abdomen, and he was confined to bed two or three days, suffering much local pain resembling peritonitis, with considerable pyrexia. The bleeding from the urethra did not continue after the second day. The testis remained swollen for several weeks, and then began to waste, until at last it was reduced to about one-third its normal size. At this time, now six years since the accident occurred, the patient reports that the testis is of the ordinary size of the organ in a boy of twelve years old. In its present condition it causes no inconvenience.

Case 2. A man, about twenty-eight years old, was quickly wheeling a barrow with two handles in the dark, when he was suddenly arrested in his course by the barrow meeting with an obstruction. The weight recoiled upon him, and shook him very much at the lower part of the abdomen. He stated that he felt something 'give way' in his right groin. Arterial blood flowed from the urethra almost immediately after; and when seen an hour after the injury, he was then bleeding. Mr. Hilton passed a catheter, and drew off perfectly clear and bloodless urine. This case was attended with nearly the same local symptoms as the last, although not quite so severe or so prolonged. It was treated in the same way, except that a few leeches were applied to the testis, and with advantage. A fortnight after the injury, the right testis was much enlarged, and slightly painful on pressure. The opportunity for further observation has not occurred.

Case 3. A gentleman, about sixty years old, was running up-stairs in pursuit of one of his children. Hoping more certainly to overtake the child, he made a violent effort to catch hold of her foot, as she was turning the corner of the stairs. This he failed to do, and fell with his knees upon the step, but did not strike the groin. He felt a sudden pain and something 'give way' in the right groin, close to the internal abdominal ring, and presently blood trickled from the urethra. Mr. Hilton saw the patient about two hours after the injury had been inflicted. He introduced a catheter into the bladder, and the urine passed through it perfectly clear and bloodless. The patient was confined to bed for nearly fourteen days, with swollen testis and pain deeply seated behind the internal abdominal ring. Leeches were applied to the lower part of the abdomen and testicle. During four or five days a small and diminishing quantity of blood passed from the orifice of the urethra. The right testis subsequently diminished very considerably; and when an examination was made, several months after the injury, it was not more than half the size of the left.

In the details of the above cases there seem to be very good reasons to concur in the opinion, that the injury sustained by these men was laceration of the vas deferens. Mr. Hilton considers that this duct is divided within the abdomen, between the internal abdominal ring and the point where it crosses the ureter, and that the blood flows from the artery which accompanies it. The blood from this vessel traverses the tube, and so enters the prostatic portion of the urethra, anterior to the bladder, thus leaving the urine free from blood.

He adduces, in corroboration of the views above expressed, the details of a case dissected by him, in which he accidentally found one testis excessively atrophied, and the vas deferens of the same gland ruptured and closed at both ends. The ends were at least two inches apart. The lowermost was lying near the crossing of its course with the ureter; the upper end was adherent to the surrounding connective tissue, near the internal ring. The vesicula seminalis on the same side was smaller than that on the opposite.

The indications of this injury are a sudden and violent pain in the groin, arising as the result of severe exertions, or of a blow; the flow of bright red blood from the urethra, although the urine which the bladder contains is free from blood; gradually increasing pain, which extends over the lower part of the abdomen, accompanied with more or less pyrexia. The bleeding ceases; the pain subsides; but the testis on the affected side becomes at first swollen and tender, and finally diminishes, until, after the lapse of a few weeks, it becomes atrophied.

Absolute rest in bed; the local application of leeches, warmth and moisture; and such constitutional remedies as serve to control and remove pyrexia, subserve the purposes of treatment, both general and local.

Cases of this injury are doubtless rare, and these have been here introduced to attract the notice of the profession.

*Injuries of the uterus.**—The following arrangement will be adopted in describing the injuries of the uterus.

In the unimpregnated state:

1. Wounds. 2. Contusions.

In the impregnated condition:

1. Wounds. 2. Contusion, without and with rupture.

Rupture during parturition:

1. Idiopathic. 2. Traumatic.

Wounds of the unimpregnated uterus are very rare. Except in combination with violent and extensive injuries to the pelvis, there are, indeed, no cases on record. As Duparcque observes, 'the fibrous, and as it were cartilaginous resistance of the womb whilst empty; the small size of the organ; its mobility, and its situation within a bony cavity, efficiently protect it from all violence capable of affecting the integrity of its walls.'

The same remarks apply to contusions of the empty organ as to wounds.

In wounds in the impregnated state, the danger depends more on the hæmorrhage which may be produced, the inflammation excited, and its consequences, and the premature expulsion of the ovum which may follow, than on the fact that the uterus is wounded. Punctured wounds, or small rents by sharp instruments, may cause the dribbling away of the amnial fluid quite as much as large injuries, thereby rendering abortion a certain result.

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* In this section I have availed myself of the knowledge of Dr. Braxton Hicks, the talented accoucheur-physician at Guy's Hospital.

Many cases of goring by cattle are on record; and from the wounds so produced, the whole or part of the fœtus has escaped into the peritoneal cavity, or completely through the abdominal walls.

Planchon relates a case of a pregnant uterus being punctured by a nail projecting from a cart. Blood mixed with the liquor amnii escaped from the wound. Death occurred in sixty hours.

Baudelocq mentions a case where the uterus was torn open by an ox, and recovery ensued.*

There is a case of recovery from puncture by a pitchfork reported in the *American Journal of Medicine*, April 1847.

The pregnant uterus has been tapped with a trocar for ascites, from which mistake no ill effects followed.

The wife of a sepoy was riding on an ox, which stumbled. She fell on its horns, one of which entered her abdomen and uterus. Through the wound the hand of the fœtus protruded. The fœtus was extracted *per vias naturales.* The intestines protruded, but were replaced, and the woman perfectly recovered.†

The uterus has also been wounded in criminal attempts to procure abortion, the instrument used passing through its walls, producing occasionally fatal hæmorrhage. A case occurred in the practice of an eminent accoucheur-physician, who examined the uterus after death, which took place from inflammation. The pointed instrument had entered the os uteri rightly, but, instead of following the axial curve, it was pushed towards the sacrum through the posterior wall of the cervix into the recto-vaginal pouch of the peritonæum.

The treatment of wounds of the pregnant uterus depends much on the condition of the parts. If the fœtus have *not* escaped, a wound of this organ must be treated on the usual principles; perfect quietude, light dietary, and full doses of opium to check pain and uterine action. If the fœtus *have* escaped, and there is yet a probability of bringing it through the natural passages, the effort must be made with the greatest care; should, however, the greater part present at the wound, then our best plan will be to draw the remainder gently through removing the placenta, as in the Cæsarean section, and finishing the proceeding, and adopting the same after-treatment, as in such cases. If only a small portion, as a limb, of the fœtus, project through the wound, it will be advisable to replace it, as early and with as much gentleness as possible; taking care, the moment labour sets in, to be ready to dilate the os uteri, either manually, or, still better, by the india-rubber dilating bags; and then as soon as the fœtus can be turned, either by introduction of the hand, or by combined external and internal version, we should deliver the fœtus, in order that it may not again be driven through the uterine walls by their contractions.

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* See Hull's *Defence of Cæsarean Section.*

† *London Medical Gazette,* Oct. 1846.

Contusions of the pregnant uterus, without rupture.—During the early months of pregnancy, blows and injuries may produce inflammation of this organ, the symptoms of which will be severe pain in the hypogastric region, extending to the vulva, perinæum, and thighs, combined with inflammatory fever. The treatment will consist in depletion, calomel and opium, and the local application of leeches and hot fomentations. Abortion is generally the result; but abscess or chronic inflammation of the womb or adhesions may be the sequel. Duparcque relates a case in which an abscess formed in front of the uterus from a blow on it in the sixth month of pregnancy. It was only discovered, after delivery, by its projection across the mouth of the uterus. It was cured by puncture with a straight bistoury.

From the changes produced in the walls of the uterus by this inflammatory action, it has been observed that injuries to that organ undoubtedly predispose to rupture in subsequent pregnancies and labours.

During the latter months of pregnancy, or at the full term, contusions give rise to inflammation of the uterus and to peritonitis. They are attended with more severe suffering if the consequent contractions be more powerful, and the child larger; and labour is almost certain to follow, impeded by the swollen uterus, and the as yet rigid os.

As to the treatment: 'Under these circumstances,' says Dr. Rigby, 'we must trust almost entirely to the lancet to aid the speedy dilatation of the os uteri; for, until the circulation has received an effectual check by fainting, the dilatation of the parts cannot proceed, nor can any attempt be made to give artificial assistance. The abdomen should be well covered with a hot linseed-meal poultice, hot decoction of poppies thrown up the vagina, the bowels opened by a simple enema, and then a warm opiate injection to allay irritation.' We would also recommend the inhalation of chloroform, but not carried to its fullest effect; and from what we have witnessed of its beneficial effects in obstetric operations, we may look for the greatest benefit: first, by its power of checking temporarily uterine contraction; secondly, from its relaxing powers to open the os; and lastly, from its anæsthetic action.

Contusions, with rupture.—This is the most serious consequence attendant on contusions to the pregnant womb. The ovum is expelled into the abdominal cavity, or more rarely through the natural passages. Besides contusions, over-exercise, leaning against hard substances, violent vomiting, and stooping and falling, have been known to cause the catastrophe.

In the early months of pregnancy the symptoms are ambiguous. They may be said generally to resemble that of rupture of any abdominal viscus. The most marked are collapse, intense pain, internal hæmorrhage, or an escape of blood from the vagina. In the latter stages of pregnancy, the symptoms point more clearly to ruptured uterus, and the child may be felt among the intestines. When death does not immediately ensue, and the case is left to nature, either fatal peritonitis is set up, with all its attendant symptoms, or the fœtus becomes surrounded with a cyst, the result of plastic effusion, and is thereby shut off from the viscera. The ovum may remain tolerably quiescent in this cyst, but sooner or later it causes irritation, and endeavours to reach the surface, either by the vagina, rectum, or through the abdominal walls.

The treatment being the same as that required when the accident occurs during labour, the reader is referred to that division (p. 746).

Rupture of the uterus during parturition.—This is one of the most appalling accidents that can complicate parturition. It may be considered under two conditions: firstly, idiopathic; secondly, traumatic. The first arises from an abnormal condition of the uterine walls, its tissue being altered by former disease, or by former wounds. It may also result from prolonged efforts to expel the child where an obstruction exists in the natural passage. Sometimes the walls give way before more than a few pains have arisen, while some patients have been four days in labour before rupture took place. The average duration of labour before rupture is about twenty-one hours.

Version, and the unskilled or careless use of obstetric instruments, not unfrequently produce the second variety of this accident. Although rash and inconsiderate attempts cannot be too strongly condemned, it is important to know that rupture has occurred even to the most skilful practitioners. From the reports of some cases it would appear that violent movements of the fœtus have given rise to this accident, though it is highly probable that the escape of the child through its walls produced the violent movements of the uterus, and thus cause has been confounded with effect. If, however, the movements were the true cause, we can hardly believe that the uterine walls were in a healthy condition at the time.

Ruptures of the uterus generally may be divided into three classes. In the first the rent is confined to the vaginal cervix, and perhaps a portion of the vagina. Occasionally the vaginal portion of the cervix has come away as a ring, having been detached from the uterus at its junction with the vagina. These cases are usually without danger; they soon heal up, and probably they are much more frequent than is commonly acknowledged. Occasionally, as in a case mentioned in the *Guy's Hospital Reports*, 1859, the hæmorrhage resulting has proved fatal. In the second class rupture is unattended with the escape of the fœtus through the rent; and in the third the fœtus escapes into the peritonæum.

The symptoms of ruptured uterus are variable, dependent on the extent of the rent, the amount of hæmorrhage attending it, and whether the fœtus has passed through its walls. The most common symptoms are a sudden sensation of tearing, or of something having given way in the abdomen, followed by fainting, and all the symptoms of collapse, cessation of the pains, frequently recession of the presenting part, frequently hæmorrhage from the vagina. These symptoms are those which more especially indicate the third class of the accident, and usually denote the escape of the fœtus into the abdominal cavity, where it can be generally felt. However, this is not always the case, for collapse may continue to a fatal end, even where the fœtus remains in utero; for bleeding into the peritonæum may cause nearly the same symptoms. Again, the uterus may be severely ruptured, and though the pains may be abated in force, they are still adequate to delivery. This termination is rare. But many cases have occurred in which it was impossible in consequence of the slightness of the symptoms to fix the time of the rupture, therefore it is not unlikely that some cases recover without the suspicion of their existence.

The treatment recommended in this formidable accident varies very much. From the researches of Dr. Trask, to whose valuable paper we must refer the reader,* it appears that in those cases where the fœtus had escaped into the peritoneal cavity,

Gastrotomy after this accident lost 24 per cent.
Turning, perforation, &c. . . . 68 „
Abandoned to nature . . . . 78 „

In a case of such difficulty, it is well to know what line of treatment affords the greatest chance of recovery; and from the above we may safely conclude that gastrotomy affords the best, which is therefore strongly urged by Dr. Trask. However, in any given case, much depends on collateral circumstances. If the child have only in part escaped into the peritoneal cavity, then it is proper to introduce the hand, seize the feet, and deliver as in version; if the head, however, be impacted in the pelvis, it is right to apply the forceps, and if that be impossible or useless, to perforate it. If the child have escaped wholly into the cavity, and only a few hours have elapsed, the hand should be passed through the rent, if it can be done with ease, the legs grasped, brought back through the rent, and delivered by the natural channels. But should much time have elapsed, or the rent be firmly contracted, so as to require some force to pass the hand through it, it will then be advisable to perform gastrotomy without delay. Again, should the escaped fœtus have, at the time of our arrival, already set up irritation, we must then wait until the plastic products of inflammation have formed a cyst around it, whereby most commonly it remains for a time comparatively quiescent. It will be a matter to determine, after waiting two or three weeks, whether we should make an opening through the abdominal walls, or delay still longer until there is a marked tendency to point forwards. In any case, should we find from the touch that the fœtus is lying just beneath the walls, there can be no hesitation in cutting down at the end of three weeks from the accident; for it must be remembered that the fœtus may take the direction of the bladder or intestines, and form openings into them, causing protracted and immense suffering. Sometimes, however, the fœtus remains in the cyst dormant for many years, but these are the exceptions.

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* 'Cases of Ruptured Uterus, with Remarks,' by Dr. Trask; *American Journal of Medical Science*, January and April 1848, and July 1856.

The intestines may escape by the rent, after delivery per vaginam, and therefore in every case examination should be made if possible, in order to reduce them when necessary; as death has taken place in some cases from strangulation of the bowel.

The laceration may take place in any direction. The relative frequency of its position is as follows:—Rupture of body and fundus, 63; ditto of cervix, involving more or less of body of uterus and vagina, 64.

Injuries to the vagina.—Unconnected with parturition, these are not very common. But few are recorded. They are inflicted by falling, or sitting upon pointed instruments, which may penetrate even to the abdomen. A case is mentioned in which a triangular hay-knife entered the vagina, lacerating the perinæum, and passed into the abdomen, whilst the long handle remained projecting from the vagina. The handle was cut short, and the remaining portion was extracted, after great difficulty, at the end of nine hours. Local and general bleeding was employed, and recovery took place in seven days.*

Two cases have been related to me in which patients have died from the hæmorrhage resulting from a wound inflicted on the vagina. It is a subject for regret that in neither case was the nature of the wound in the artery discovered after death, by careful dissection.

My informant was hastily summoned to a lady, whom he found lying on the floor in a pool of blood, at the point of death; in fact, she scarcely breathed after his arrival. The husband had left her in perfect health, a very short time before, to accompany a friend a little distance from the house. On his return, he found his wife on the floor, and faint. A surgeon had seen the patient, and discovering a flow of blood from the vagina, placed a compress and plug of lint therein, and gave stimulants. The hæmorrhage, however, continued, and death took place about an hour after the infliction of the injury. A post-mortem examination of the wound *only* was made. On separating the labia, a lacerated wound, which extended upwards and forwards, was seen, and the internal pudic artery was found to have been divided. The accident was occasioned by the lady going into a dark bedroom to micturate, and sitting down upon a water-ewer, the handle of which was broken off, leaving a portion, sharp, jagged, and projecting about an inch, which produced the injury.

Mr. Durham, assistant-surgeon at Guy's Hospital, related to me the following case: A woman was knocked down by a man, and immediately a large pool of blood appeared on the floor. She died in a short time. The blood flowed from the vagina, in the walls of which there was a wound extending towards the internal pudic artery. At first it was thought that the woman had been stabbed with a knife, but on careful examination it was discovered that she had fallen on a spittoon. The weight of her body broke this utensil, and a sharp-pointed fragment of it probably inflicted the injury.

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* *Lancet,* 1833–34, vol. ii. p. 112, from *Revue médicale.*

Injuries connected with parturition.—Rupture of the cervix uteri frequently extends into the vagina, assisting the escape of the fœtus into the peritoneal cavity, or allowing the intestines to protrude. Sometimes the vagina alone is ruptured in a circular direction, either posteriorly or anteriorly, close to the bladder. The rupture frequently extends half way round, not very infrequently three-fourths of its circumference. The symptoms in such cases resemble those of ruptured uterus, and must be treated accordingly.

Two cases are latterly * on record where the uterus has been detached from the vagina, and expelled from the body during labour. In both these cases there was an inquest. It did not appear that any force had been applied to the parts: at least not sufficient to account for such an injury. Upon consideration of the forces employed in labour and of the partial laceration of the vagina, which has occurred through two-thirds of its circumference spontaneously, we may find a legitimate explanation of this accident in the enormous strain on the round ligaments and vagina after the head of the fœtus has passed through the os uteri, but is arrested by the pelvis. The vagina and round ligaments form the only restraint of any importance against the recoil of the uterus; if any part give way, then undue strain falls on the rest; and if the uterus then continue in action, its force, so useful to expel the fœtus, acts against these restraining tissues, till they yield. In general the ruptures of uterus and vagina cause suspension of the pains, and then the extension of the mischief ceases; but this is not always the case, and then the rupture is rapidly extended.

The unskilful use of obstetric instruments, or the extraction of the broken-up fœtal cranium, have often caused severe injuries to the vagina; sometimes the former have passed through the walls, at the junction of the cervix, tearing the uterus from the vagina.

In a case of this kind the forceps passed through the vagina behind the os uteri; the intestines protruded, and attempts were made to reduce them. They, however, continued to fall down, and the portion protruded sloughed off in about ten days. Ultimately the patient recovered with an intestino-vaginal fistula. This, after two years, was closed by a plastic operation, and then the motions passed for the first time since the operation by the rectum. There was, however, no doubt that some inches of perfect intestine had come away originally.

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* See *Lancet* and *Brit. Assoc. Journ.* 1st half-year, 1869.

In attempts to procure abortion, the vagina has been injured, and occlusion or constriction of the passage being the result, has been detected at the subsequent labour.

The vagina has also been torn, together with the hymen, in the attempts at coitus for the first time.* In two cases described to the writer, in recently married women, the bleeding was very alarming to both parties, consequent upon the tearing up of a considerable portion of the mucous membrane. Similar effects are also produced in rape. The legal points of these cases may be seen in works on Medical Jurisprudence.

The passage of the child's head in primiparæ will occasionally push before it the internal membrane of the perinæum, so as to cause it to tear, leaving a raw surface internally, which is difficult and slow to heal. In two instances this caused contraction and severe pain afterwards. In one case coitus was impossible for nine months at least after labour. The irritation of the lochia probably retards the healing process.

All these wounds require but little surgical interference beyond the injection of warm fomentations, great cleanliness at first, and, if they be slow to heal, some stimulating injection, as black-wash, zinc and alum lotion, a lotion of nitrate of silver, or the application of the solid nitrate.

All injuries of the vagina are exceeding prone to be followed by contracting cicatrices, which in part or even wholly occlude the passage, rendering coitus more or less difficult, painful, and even impossible. They add very seriously to the dangers of labour, ending even in rupture of the uterus.† Peritonitis is apt to follow injuries of the vagina, especially if they be near the uterus. Any symptoms, therefore, of this disease must be carefully watched.

The protracted detention and pressure of the child's head within the vagina is sometimes followed by a slough, which may extend anteriorly into the bladder, causing vesico-vaginal fistula; or posteriorly into the rectum, causing recto-vaginal fistula. By the former the urine passes in part or wholly into the vagina; and by the latter the fæces, rendering the condition of the sufferer very pitiable. The treatment of the results of this injury is described in the essay on SURGICAL DISEASES OF WOMEN.

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* A specimen of this injury, which proved fatal, is preserved in the collection of obstetric preparations presented by Mr. Stone to the Museum of St. George's Hospital.

† Trask on 'Occlusion of the Os Uteri and Vagina,' in *American Journal of Medical Science*, July 1848.

Foreign bodies when lodged in the vagina require some skill in extracting them. The most common is the pessary, the strings of which break, and the patient, from ignorance, generally allows it to remain until the discharge becomes most offensive, simulating that from malignant disease. Severe irritation is also set up; and after a time the vagina may become so contracted around it, that it is exceedingly difficult to introduce any instrument to take hold of it. In one case the pessary had to be sawn in two parts, by a saw introduced into the vagina, before it could be removed. In another, a metal pessary was so impacted that the perinæum required division to facilitate its removal. For ordinary cases a forceps made for the purpose is best.

In the *London Medical Gazette*, 1854, p. 264, a case is reported where a broken neck of a bottle was found in the vagina. A point of it had entered the bladder, and on this point a calculus had formed as well as around the part in the vagina. A glass bottle was removed by the writer with polypus forceps. An ale-glass, two inches and a half in diameter and three in height, was removed by the forceps, and the case is reported in the *Lancet*, 1856, vol. ii. p. 451. At Guy's Hospital a case occurred, under the care of Mr. Hilton, in which a flat bone netting-mesh, about ten inches long, was successfully removed from the pelvis of a girl, who had introduced it into that region per vaginam. The length of the mesh necessitated its division into two parts before it was removed. The mesh is in the Museum at Guy's Hospital.*

Injuries to the *vulva and external parts* arise from kicks, falls astride, sitting on sharp instruments, fire, rape, and the passage of the child's head. They must be treated upon the ordinary principles of surgery. As these parts contain much connective tissue, they very readily swell after injuries, and suppuration also extends widely and quickly throughout their tissues. As the vascularity of these organs is great, contusions give rise to large extravasations of blood, which cause remarkable discoloration of the skin for some distance around. By the application of cold at first, and subsequently a stimulating lotion, the blood soon becomes absorbed. As the result of cicatrisation after burns, the entrance to the vagina may appear to be nearly closed up. But mechanical dilatation removes the deformity.

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* *Med.-Chir. Trans.* vol. xxxi. p. 315.

Injuries of the perinæum.—In the male sex this region is liable to contusions and superficial lacerations. Boys are particularly the subjects of injuries in this part of their bodies, which occur in scrambling over rails or palings; and adults frequently bruise the part by striking it upon the pommel or some other part of the saddle in riding. The result is more or less effusion of blood into the loose connective tissue, and the appearances termed ecchymosis become visible in a day or two. Local pain or tenderness generally accompanies the swelling which results, with slight difficulty and perhaps pain in micturition. Retention of urine sometimes occurs from the mechanical pressure of the swelling upon the urethra, and therefore in children especial care should be observed to ascertain that the bladder is emptied.

Repose, and the local application of warmth and moisture, or a lotion of the liquor plumbi diacetatis dilutus, is usually all the treatment that is required.

Incised and even lacerated wounds of the integuments and deeper tissues of the perinæum usually heal favourably, when treated in the manner applicable to the special case, and therefore their treatment requires no particular description here. The surgeon should, however, bear in mind the relations of the urethra to this region.

But although the primary results of a wound in the male perineal region cannot be regarded as more serious than other superficial wounds of soft parts, yet the secondary results may involve considerable risk to life. The proximity of the wound to the urethra causes the inflammation resulting from it to extend to that canal, and thus there may be excited, from an apparently trivial cause, all the dangers and difficulties accruing from retention of urine, and the usual means may be required to relieve that condition.

Let the following case illustrate this point.

A rather weak man, twenty-two years old, was admitted into Guy's Hospital in 1838, with a lacerated wound of the perinæum, which penetrated merely to the muscles. The injury had been inflicted by falling off a chair and striking the perinæum. At first a catheter was passed without any difficulty, but by degrees this operation became impeded by surrounding inflammation. The urethra was at last involved in the mischief, and by the introduction of a catheter it was supposed that a false passage was established. The urine escaped into the connective tissue of the perinæum, and a large abscess was the result. The appetite of the patient had entirely failed soon after the accident, and great constitutional disturbance had resulted. At last hectic fever, with colliquative diarrhœa, supervened, and he sunk in sixteen days after the receipt of the injury. Post-mortem examination showed that the tissues of the heart, lungs, liver, and kidneys were diseased. The cavity of a large abscess existed between the bladder and rectum, and into the last viscus there was an opening. The mucous membrane of the bladder and urethra was covered with false membranes, and there were abscesses in the walls of the bladder.

The perinæum in the female sex is liable to a much more serious injury during parturition. Placed behind the vulva, the integuments and subcutaneous tissues are so much stretched during the passage of the child's head, that they are unable to offer sufficient resistance, and they become torn or lacerated. The direction of the rent is either immediately backwards, central, or a little to one side or the other. Should this accident occur, the edges of the wound may be brought together with sutures, and a fair chance of cicatrisation exists. But if neglected, the surfaces heal over, and a permanent fissure will be the result. Even when the torn surfaces are covered with granulations, their suitable adjustment with the quill-suture may induce cicatrisation.*

This subject will be found more fully treated in the essay on Surgical Diseases of Women.

(C.) Injuries of the Rectum and Anus.

Incised wounds of this portion of the alimentary canal usually heal very readily. An illustration of the fact may be taken from the observation of incisions made into the bowel for the cure of fistula in ano, and of those in which the anterior wall of the bowel is incised, to permit the extraction of a large stone from the urinary bladder. Even instances in which the rectum has been accidentally wounded in the lateral operation of lithotomy might be mentioned, to show how readily such wounds heal.

The rectum is sometimes injured by the introduction of bougies, or the ends of enema syringes.

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* See a case in *Guy's Hospital Reports*, 1855, p. 184.

In the Museum at Guy's Hospital there is a portion of rectum perforated by a bougie. The patient had been affected for many years with stricture, and had often been relieved by surgical aid; at length, in an attempt to pass the bougie himself, he perforated the rectum, and death ensued in about ten hours.

In another case the same injury was inflicted by the introduction of an O'Beirne's tube. The wound was about five inches from the anus. A man, aged sixty-seven, was the subject of strangulated hernia. It was supposed to be reduced, but the symptoms of strangulation continuing, a rectum bougie was passed. Collapse and death followed. After death the rectum was found perforated, as the preparation shows.*

As an effect of perforation, the lower part of the abdomen may become emphysematous. A case of this kind was under the care of the late Dr. Hughes. A man, aged fifty, was admitted into Guy's Hospital in 1856, with cancerous disease of the pylorus. The necropsy revealed ulceration of the rectum, which had occupied nearly the whole of its lower third; the surface of the ulcer was irregular and ragged, and formed irregular bands and pouches. Beneath one of these bands, consisting of muscular fibre, was a small opening into the cellular tissues; this opening the patient had made with an enema syringe, and it had led to emphysema of the whole of the lower half of the abdomen. The preparation is in Guy's Hospital Museum.

As a secondary result of the wounds of the rectum and anus, peritonitis must be mentioned. If phlegmonous erysipelas attacks the wound, and extends into the connective tissue of the pelvis, the inflammation may reach the reflection of peritonæum passing from the bladder to the rectum. Spreading from this point, it diffuses itself over the whole extent of this serous membrane, and death ensues. This complication is rare, but I have witnessed its occurrence.

Wounds of this region implicating the urinary bladder have been alluded to above. As an unusual result attending the operation of paracentesis vesicæ by the rectum, may be mentioned emphysema, extending to the upper parts of the body.† This complication must be, however, very rare, since it has never occurred once in numerous operations performed in Guy's Hospital.

Foreign bodies in the rectum may be divided into two classes:

1. Those composed of materials which have passed first along the upper part of the alimentary canal.
2. Those introduced at the anus.

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* The preparation is in Guy's Hospital Museum.

† Two cases are related in the *Lancet*, January 1860, p. 89.

1. To the first class belong small bones, or pieces of bone; hard bodies, as fruit stones, which may or may not be covered with accumulations of fæcal matter; large bodies composed of hardened fæces; and concretions of substances taken as medicine, such as masses of magnesia.

The indications of the existence of such foreign bodies as above described are—pain in attempts at defæcation; a sense of weight and fulness at the anus, as of something there which cannot pass the orifice; the habitual and often-repeated passage of loose mucous stools, occasionally a little blood; and the development of external hæmorrhoids. By introducing the index-finger a hard solid mass is felt.

Such hard masses require to be removed with care. To accomplish this, the bowel must be well lubricated with oil, and warm water injected into the rectum. If these plans fail to dislodge the irritating cause, mechanical means must be employed, first to break the solid body, and then to remove it piecemeal.

2. Foreign bodies introduced per anum are of various kinds. The patient probably being always aware of the nature of the body so impacted above the sphincter ani, will be able to assist the surgeon who has to extract it, by giving some account of its structure and form. The surgeon must then exercise his own ingenuity in regard to the removal.

JOHN BIRKETT.

INJURIES OF THE UPPER EXTREMITY.

ONE of the principal physical characteristics of man is the extensive development and varied application of the upper extremity. When we consider that it is chiefly by the wonderful power and versatility of movement enjoyed by the hand and arm, that the mandates of his intellectual nature are carried out, and its evidences impressed on the material creation, and moreover, that this member is so situated as to be constantly interposed for the protection of otherwise defenceless vital organs, it will not seem surprising that injuries are met with more frequently in this, than in any other part of the human frame. The greater number of these, of course, present no special characters which distinguish them, either in their nature or treatment, from similar injuries occurring in other parts of the body; hence it will only be necessary in this essay to treat fully of those, the particulars of which depend upon, or are modified by, the anatomical constitution of the part affected.

The frequent and comparatively slight injuries called *bruises* or *contusions*, may be met with in the upper extremity in every variety of severity, but call for no especial remark on their nature and treatment. The same may be said of the effects of intense heat and cold, *burns*, *scalds*, and *frost-bite.* The ends of the fingers are liable to the latter affection under the same circumstances as produce it elsewhere, but, as a general rule, are not so readily attacked as the corresponding parts of the lower extremity.

SPRAINS.

Sprains are very frequent in all the joints of the upper limb, especially in the wrist, and articulations of the thumb, as these parts are much exposed in falls, when the arms are instinctively thrown out to protect the head and chest. The bones being forcibly bent upon one another, if actual dislocation be not produced, a severe strain of the ligaments, often attended with rupture of some of their fibres, will take place. This is not unfrequently followed by inflammation of the synovial membrane and other structures connected with the joint, sometimes of a very intractable nature. Even when the active inflammation is subdued, a relaxed and permanently weakened condition of the part will often remain. Neglect in the early period of the treatment is a frequent cause of the trouble that such injuries give rise to afterwards, it being very difficult to convince patients of the necessity of submitting to the inconvenience of keeping the joint in a complete state of rest, for what seems at first a trifling injury. The continuous application of ice (for which the caoutchouc bags recommended by Esmarch are very useful) greatly relieves the pain and cuts short the period of acute inflammation; but the ice must be constantly applied without intermission, otherwise it rather does harm and fomentations are preferable. When the pain has abated, uniform compression of the joint with a roller or adhesive strapping will promote the subsidence of the swelling, and will allow the patient some use of the limb sooner than would be safe without this support. Stiffness, so troublesome after these injuries, is best overcome by passive movement and friction with stimulating liniments.

The *muscles* appear to be sometimes the seat of sprains. After violent exertion, as rowing, lifting heavy weights, &c., some particular muscle, or group of muscles, is found to be swollen, tender, or perhaps painful, especially when any movement brings it into action. Similar causes occasionally produce *rupture of the muscles*, either entirely or in part. The muscles of the upper extremity in which this has been observed, are the pectoralis major, deltoid, triceps, and more frequently the biceps.

Rupture of tendons is an accident about which much has been written, especially with reference to the long tendon of the biceps, which would appear to be especially obnoxious to this injury. Mr. Callaway* has fully described the symptoms attendant upon it, and has collected twenty-two cases, in which on post-mortem examination the upper part of the tendon had apparently been torn; but the researches of more recent pathologists have shown that one of the most constant effects of the not unfrequent disease of the shoulder-joint, called by Dr. R. Adams of Dublin 'chronic rheumatic arthritis,' is disorganisation and ultimate destruction of the intracapsular portion of this tendon. In the absence therefore of any history of injury, and taking into consideration the other pathological changes which were found in the joints examined, the greater part, if not all, of the so-called cases of rupture of the longer tendon of the biceps may reasonably be supposed to have been the result of this disease.* In the opinion of the last-named surgeon, the reported cases of dislocation of the long tendon of the biceps with partial displacement of the head of the humerus upwards,† are also to be classed as the effects of disease, and not of injury; but the proof of this appears to me not quite so satisfactory as in the former cases.

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* *Dissertation upon Dislocations and Fractures of the Clavicle and Shoulder-joint*, p. 144.

In connection with this subject, a curious injury may be mentioned, which has been described as *displacement of the inferior angle of the scapula* over the edge of the latissimus dorsi muscle, and is stated to be caused by raising the arm above the head to an unnatural extent. The only fully reported cases that I have been able to collect of anything analogous to this, are, one by Mr. Banner,‡ another by Mr. Rose,§ and a third, which occurred in 1859 among the out-patients of the Middlesex Hospital, and for the particulars of which I am indebted to Mr. W. H. Rix, at that time house-surgeon. None of these cases, however, exactly correspond with the description given by Liston;‖ for although the posterior border and inferior angle of the scapula projected very markedly, there was no distinct account of any injury, and the affection seemed rather to be paralysis of the muscles attached to this part of the bone, especially of the serratus magnus. In the last-mentioned case the subject was a delicate-looking girl of fourteen; the whole of the posterior border of the right scapula was very prominent, and seemed to meet the skin covering it, almost at a right angle. The inferior angle only projected a little more than the rest of the border, but the fingers could be passed fairly beneath it. The scapula could easily be pressed into the proper position, but it immediately started back again when left to itself. The motions of the arm were weakened and impaired. The treatment of such cases consists in the application of a bandage round the chest to keep the scapula in place, and galvanism to restore the tone of the affected muscles. I have seen a few similar cases. In all the projection of the lower angle of the scapula was apparently due to atony of the muscles attached to the vertebral border of the bone, and in no instance was there a history of an antecedent injury.

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* See R. Adams' *Treatise on Rheumatic Gout*, 1857, and art. 'Abnormal Conditions of the Shoulder-joint,' in *Cyclop. Anat. and Phys.*; R. W. Smith, *Dublin Quarterly Journal of Medical Science*, Feb. 1853; E. Canton, *London Medical Gazette*, 1849, vol. viii. p. 958.

† See a paper by J. Soden, jun., *Med.-Chir. Trans.* vol. xxiv. 1841.

‡ *Trans. Prov. Med. and Surg. Association*, vol. xi. 1842.

§ *London Medical Gazette*, vol. xlv. 1850.

‖ *Elements of Surgery*, 1832, part iii. p. 321.

WOUNDS.

The hand and arm, from their frequent exposure, are liable to every kind of wound, nearly all of which are amenable to the ordinary modes of treatment. All varieties of poisoned wounds are of course more often met with here than elsewhere, though their frequency is exaggerated, in consequence of whitlows and other local manifestations of peculiar constitutional conditions being generally attributed by the sufferers from them, to such an origin. When, from whatever cause, suppuration has taken place in the hand or fingers, the importance of early and free evacuation of the pus cannot be too strongly insisted upon, as it is often confined beneath the dense fasciæ, and being thus prevented from reaching the surface, extends along the course of the tendons, causing extensive disorganisation of all the tissues, and frequently terminating in sloughing of the tendons, or necrosis of some of the phalangeal bones.

According to M. Nélaton, abscesses of the fore-arm develop themselves most commonly after wounds or inflammations of the thumb, or little finger, 'rarely after wounds of the other three fingers; and the anatomy of the parts, which shows that the sheaths of the flexors of those fingers do not communicate with the sheath under the annular ligament under the wrist, explains the reason.'* The same surgeon also remarks, that in examining for pus in this part, it is necessary to make palpation in the long diameter of the limb; as, if the fingers are placed transversely, the sensation caused by the displacement of the muscles is very deceptive. If the abscess is deeply seated, in order to obtain a free opening, and to avoid wounding nerves, vessels, or tendons, M. Nélaton directs that an incision should first be made through the skin three inches in length, then the aponeurosis slit open upon a director over an interstice between two muscles; the latter may then be separated, and the opening enlarged, if necessary, by introducing the end of the finger.

Needles often run into, and break off in, the hand, causing sometimes much trouble in extraction, especially if the piece be small, and have penetrated deeply into fleshy parts, as the ball of the thumb. The position of the foreign body must be ascertained as well as possible, by searching for the wound by which it entered, and by carefully feeling for its ends through the skin. If its situation can be ascertained with tolerable certainty by these means, it must be cut down upon, and drawn out with the forceps; but care must be taken not to drive it farther in during the attempt at extraction, and all unnecessary or speculative incisions in a part so well supplied with nerves and vessels as the palm of the hand must be avoided. Time and some suffering is saved to the patient, if it can be found and extracted at once; but if, after a thorough examination, it cannot be discovered, we must wait until it shifts its situation and it can be felt, allaying the inflammation and pain with poultices and anodynes.

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* *Clinical Lectures on Surgery*, edited by Walter F. Atlee, M.D. Philadelphia, 1855.

Lacerated wounds about the hand are the cases commonly supposed to be especially liable to be followed by tetanus; yet I think that if we examine the assigned causes of many cases of traumatic tetanus, allowing for the great comparative frequency of such injuries, we shall hardly find that wounds of the hand bear any disproportionate ratio to those of other parts.

In incised and punctured wounds inflicted by carpenters' tools or knives accidentally slipping from the hand, or by broken glass, the radial or ulnar arteries are not unfrequently divided near the wrist; but the treatment will be conducted entirely in accordance with the general principles applicable to wounded arteries. See vol. i. p. 749.

The bleeding from wounds of the deep palmar arch is apt to be very troublesome, on account of the difficulty often experienced in finding the divided extremities of a vessel placed at a considerable depth from the surface, close to the bone, and in a wound which, owing to its anatomical relations, cannot be freely enlarged. Therefore, in this case it is necessary sometimes to depart from the rule, almost universal elsewhere, of tying the vessel at the seat of the injury, and to seek some other method of restraining the hæmorrhage. In the first place, a graduated compress should be laid over the wound: this is kept in position by two small wooden splints placed transversely across the hand, one on the palmar and one on the dorsal side, a good pad of lint being placed beneath the latter, while the former rests upon the compress; they may then be brought together to any degree of tightness, by strips of adhesive plaster round their extremities. Then the current of blood through the radial and ulnar arteries should be restrained, either by pieces of thick bougie, or by small rollers laid lengthwise over the course of the vessels in the lower part of the fore-arm and confined by a bandage. A third larger roller, placed between the others, is often a useful adjunct in keeping these in place, by preventing the bandage from forcing them towards each other. Extreme flexion of the elbow, which checks the flow through the brachial artery, is preferred by some surgeons. The patient should, if possible, be kept in bed, with the hand raised high above the level of the rest of the body. If secondary hæmorrhage come on, the compress must be taken off, the wound well cleansed from clots, &c., and the apparatus readjusted. Close observation of each case alone will teach to what extent, and for how long, pressure may be applied to the wound without fear of producing sloughing of the tissues. This so generally occurs when the wound has been plugged with compresses, wetted with the strong acid solutions of the persalts of iron now in common use, that the practice cannot be recommended. If these means fail to stay the bleeding, ligature of the arteries of the fore-arm in their lower third, or of the brachial a little below the middle, must be adopted. Opinions are much divided as to which is the preferable operation. Most surgeons use the latter only as a *dernier ressort*; while others, finding that if both radial and ulnar are tied, circulation in the hand is still maintained by the interosseous artery, which is secured with difficulty, prefer the single and simpler proceeding of at once tying the brachial. My own experience, drawn from the observation of several cases, is in favour of tying the radial and ulnar arteries just above the wrist, unless the fore-arm is greatly inflamed and swollen.

Severe lacerated wounds, with or without fracture, as well as wounds of joints, should be treated according to general principles, recollecting, however, that such injuries are endured and recovered from, far more readily in the upper, than in the corresponding parts of the lower extremity. Not only is the reparative power more active, but there is also the advantage of their not requiring the patient to be confined to bed, with consequent deterioration of general health, during the whole of the treatment. Numerous instances of most severe compound fractures and dislocations implicating the elbow or wrist joint, which at first sight appeared hopeless, have by careful treatment completely recovered.

The records of military surgery will furnish many such. As a good example of the extent of reparative power, when aided by judicious treatment, I may quote one related by Sir James Prior, Deputy-Inspector of Hospitals and Fleets,* which occurred in civil practice. A man, aged thirty-four, working in a dock-yard, received a violent blow from the rapidly-revolving handle of a windlass, on the under side of the left arm, at the elbow-joint. 'There was a large wound on the under surface of the joint, occasioning a general disconnection of its parts, muscular and otherwise, excepting immediately in front. All the ligaments also were obviously torn asunder; the heads of the radius and ulna were driven wholly from their situations, upwards and forwards on the humerus; the condyles of the latter bone, and part of its shaft, to the extent of two and a half or three inches, projected behind from the wound at nearly a right angle with the fore-arm, and as thoroughly denuded of all ligaments and muscular attachments as if cleaned with the scalpel.' The brachial artery and nerves of the arm being uninjured, it was determined to attempt to save the limb. The bones were easily reduced, the wound carefully brought together, and treated with cold applications. The patient eventually recovered with a very efficient limb, and went back to his laborious employment.

Primary amputation is very rarely required in cases of compound fracture or dislocation involving the elbow-joint—never, indeed, unless the artery be torn through, or the soft parts in front as well as behind the joint extensively damaged. In treating such injuries, the position most favourable and convenient to the patient, that of semi-flexion, should be adopted, the arm being fixed immovably on a gutta-percha splint, which may be cut away, opposite the wound, so as to allow of the application of the dressings; and the fracture or dislocation being reduced and any loose fragments of bone removed, the wound should be thoroughly washed with a solution of chloride of zinc or carbolic acid; its edges should be brought together as neatly as possible with wire sutures, and treated with cold applications, especially ice, if there be much inflammatory action. When the bones are much comminuted, and the external wound is small, it is best to enlarge it freely, and excise the injured ends of the bone, as much less constitutional disturbance follows cases so treated, and a false joint with a very considerable amount of motion will be formed.† Wounds of the wrist-joint should be treated on the same principles, the fore-arm and hand being fixed upon a straight splint.

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* *Lancet*, December 1844.

† See an interesting series of severe injuries to the elbow-joint, in London and Provincial Hospitals, collected by Mr. J. Hutchinson, *Medical Times and Gazette*, 1856, vol. ii.

Compound fractures of the humerus, if attended with much laceration of soft parts, especially lesion of the artery and of the great nervous cords, sometimes require amputation; but the fore-arm when similarly injured may almost always be preserved.

The hand is very frequently the subject of extensive crushes, involving bones as well as soft parts, and often requiring the removal of one or more of the fingers or of the whole member. Great ingenuity may be displayed in the performance of the operation in such cases, the surgeon being guided in the amount to be removed and the selection of flaps by the extent of the injury, always remembering the necessity of saving as much as possible. The loss of one or two fingers is not of great moment, except in some peculiar occupations; but the thumb is of especial importance, and if only a single finger is left to oppose it, great use may still be made of the hand. It is even better to save the thumb alone or a single finger when it can be done, than to sacrifice the whole hand. Although everything that is likely to be of service must be carefully preserved, the opposite error must be avoided of attempting to save, at a great sacrifice of time to the patient, a severely injured finger, which, although it may ultimately heal, will remain permanently stiff or deformed, and which, from its being either useless or positively interfering with his employment, may eventually have to be removed. Among people of the upper classes of life, even elegance of appearance is an element of consideration. On the latter account, when a finger has to be removed entire, the head of the metacarpal bone, although uninjured, is often taken out with it, so that the remaining fingers come nearer together, and the loss is less conspicuous; but with working people, this should not be done, as to them a broad palm is often an advantage; and the hand is weakened by the division of the transverse ligament which connects the head of the bones. In compound dislocations of the phalanges, in which attempts at reduction have been unsuccessful, it is better to remove the projecting head of the displaced bone, then to bring the wound together, and fix the finger on a splint, trusting to the formation of a ligamentous joint.

STATISTICS OF FRACTURES AND DISLOCATIONS OF THE UPPER EXTREMITY.

Nearly all statistical information hitherto published regarding fractures and dislocations is more or less unsatisfactory, either because the numbers given are too limited, or the cases being selected, they do not present a fair average of all ages and classes of the population.

The following table has the advantage of showing nearly every case which presented itself during a given period at a hospital so situated as to afford a fair example of the ordinary accidents of civil life in this country. Some few have been rejected on account of insufficiency of diagnosis, or omission of age or sex from the record, and doubtless the remainder are not entirely free from errors; such errors, however, correct themselves when the numbers are sufficiently large. In one class only is there a considerable defect, viz. the fractures of the phalanges; many cases that are vaguely entered in the hospital books as 'smashed' or 'crushed' fingers, without specification of lesion to bone, having been omitted from the table. If all these were added, the numbers assigned to this injury would probably be doubled.

It is not within the scope of a work like the present to discuss all the inferences that might be derived from the study of this table. A few general observations on the influence of sex and age upon the production of these injuries, will, however, be admissible.

It will be seen, as might be expected from the difference of habits and occupation, that the whole number of males exceeds that of females, the ratio being that of 10 to 6·2; but this ratio is not constant in all kinds of injury, and all periods of life. During infancy there are 200 males and 197 females; so that, as might be supposed, in this period the liability to these accidents is the same in both sexes. This age is characterised by the great frequency of fracture of the clavicle, more than half of the entire number of injuries belonging to this bone. The bones of the fore-arm and humerus follow next in order; but fractures of the olecranon, metacarpus and phalanges, and all dislocations, are almost unknown. During the succeeding ten years we find the active disposition of boys exposing them to frequent fractures of the clavicle, humerus, and fore-arm, and to dislocations of the elbow-joint; while with the opposite sex such accidents are comparatively less frequent than at any other period, the proportion being now as 10 to 2·7. In the

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Fractures and Dislocations of the Bones of the Upper Extremity, treated at the Middlesex Hospital, during sixteen years ending June 30, 1867.

A. Fractures.

	Age. 0 to 5.		Age. 5 to 15.		Age. 15 to 30.		Age. 30 to 45.		Age. 45 to 60.		Age. Above 60.		Total.		
	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	M. and F.
Scapula . .	5	3	3	—	1	1	11	6	7	—	1	1	28	11	39
Clavicle . .	176	171	84	47	56	26	67	33	51	33	18	10	452	320	772
Humerus Upper end .	1	4	7	2	5	—	11	5	8	4	5	8	37	23	60
Humerus Shaft .	39	22	42	17	27	18	25	16	11	16	6	15	150	104	254
Humerus Lower end .	8	4	46	3	14	2	2	2	5	1	1	1	76	13	89
Olecranon .	1	—	7	2	23	3	14	5	8	4	4	5	57	19	76
Ulna (excluding Olecranon) .	8	7	19	1	7	6	19	10	13	10	2	5	68	39	107
Radius alone	62	64	92	19	78	45	75	57	45	123	21	87	373	395	768
Ulna and Radius .	20	17	71	11	15	7	8	9	9	12	4	8	127	64	191
Carpal bones	—	—	—	—	—	—	1	—	—	—	—	—	1	—	1
Metacarpal bones .	1	1	10	1	62	9	50	13	15	3	3	—	141	27	168
Phalanges	3	2	44	7	47	8	32	13	24	5	4	1	144	36	180
Total .	324	295	425	110	335	125	315	169	196	211	69	141	1654	1051	2705

B. Dislocations.

	Age. 0 to 5.		Age. 5 to 15.		Age. 15 to 30.		Age. 30 to 45.		Age. 45 to 60.		Age. Above 60.		Total.		
	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	M. and F.
Clavicle . .	1	—	2	1	4	—	2	1	2	1	2	—	13	3	16
Acromion .	—	—	1	—	3	—	3	1	3	1	—	—	10	2	12
Humerus .	1	2	1	1	24	9	63	21	42	34	36	28	167	95	262
Elbow . .	—	1	43	5	8	3	8	3	2	—	—	—	61	12	73
Thumb . .	—	1	11	3	18	3	23	11	15	10	3	1	70	29	99
Phalanges of Fingers .	—	—	6	2	11	3	6	11	7	7	3	3	33	26	59
Total .	2	4	64	12	68	18	105	48	71	53	44	32	54	167	521
Fractures and Dislocations	326	299	489	122	403	143	420	217	267	264	113	173	2008	1218	3226

next period, that from fifteen to twenty years, the males exceed the females in the proportion of 10 to 3·7, and this excess steadily decreases, till, between forty-five and sixty, the sexes figure in nearly equal numbers; and beyond that age the liability to these accidents is considerably greater among women than among men, this preponderance being almost entirely owing to the great frequency among the former of fracture of a particular part of one bone, viz. the lower end of the radius.

Further reference to the numbers in the table will be found under the head of each particular injury.

Fractures of the Bones of the Upper Extremity.

Fractures of the Clavicle.

The clavicle is more frequently broken than any other bone in the body, the radius excepted. Although met with at all ages, this accident is most common in infancy and early childhood; nearly one-half of the entire number of cases recorded in the above table occurred before the completion of the fifth year. Up to this period its relative frequency in the different sexes is nearly equal; at all subsequent ages men are much more liable to it than women.

Sometimes the fracture is caused by direct application of force to the bone, as by a heavy blow, or a wheel passing over it, or a fall in which the body of the bone comes into contact with some hard substance; but much more commonly it is due to indirect violence, as falls on the point of the shoulder, or on the hand when the arm is outstretched: in the latter case the shock is transmitted through the other bones to this, the last in the series, which being fixed at its proximal end to the sternum, must give way under a sufficient amount of force. Dr. F. H. Hamilton* has collected six, and Gurlt twenty cases of fracture of the clavicle from muscular action.† The last author has also brought together seven cases of intrauterine fracture of the collar-bone produced by external violence.‡

The bone is generally broken near the middle, although it may be towards the acromial, or more rarely the sternal extremity. The line of fracture is said to be usually transverse, but in many specimens that I have examined in museums, it has passed in a straight line from the deepest part of the concavity of one curve to that of the other, and therefore very obliquely across the shaft of the bone, and inclining from within upwards, so that the inner fragment overlaps the outer. The part between the two curves is generally the weakest part of the bone, and hence more liable to fracture. When the clavicle is broken near its middle, the inner fragment is usually retained in its place, because the strong ligaments attached to its sternal end prevent much movement, and the muscles connected with it nearly counterbalance each other. There is, however, a slight tendency to elevation of the outer end, which in cases left long neglected becomes very marked. I lately saw a girl, aged nine, who had broken her clavicle a month before, and had had no treatment; the sternal fragment projected upwards at an angle of 45°, its sharp extremity forming a visible prominence in the side of the neck. The other fragment was fully an inch below this, and connected with it by what appeared to be a band of fibrous tissue, passing nearly vertically between them.* The outer fragment usually falls below its normal position, owing to the weight of the arm, and it is drawn inwards by the muscles passing from the chest to the shoulder and humerus, the outer end being turned somewhat forwards; its broken end is, in the great majority of cases, placed beneath that of the sternal fragment, though it occasionally, but very rarely, is found above† or anterior‡ to it. If the fracture is oblique, the fragments generally ride, and the whole bone is somewhat shortened. The diminution in length of clavicles that have united after oblique fractures is sometimes more than an inch.

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* *A Practical Treatise on Fractures and Dislocations*, p. 180, Philadelphia, 1860.

† Gurlt, *Handbuch der Lehre von der Knochenbrüchen,* Th. 2, L. 2, p. 593 et sqq.

‡ Gurlt, loc. cit. Th. 2, L. 2, pp. 595–6.

The signs usually presented are very characteristic, and except in the case of young fat children, there is rarely much difficulty in the diagnosis. There is pain at the seat of injury; the patient is unable to lift the arm to the head, or to move it extensively forwards or backwards, at least without much suffering; his neck and head are usually inclined to the injured side; while, to relieve the pain caused by the displaced fragments of bone, he will often support the elbow with the opposite hand. The point of the shoulder falls lower than the other, and somewhat forwards and inwards, its distance from the centre of the sternum being diminished in proportion to the amount of riding of the broken fragments. On passing the finger along the upper border of the clavicle, the abrupt projecting end of the inner fragment and the depression of the outer one are easily recognised, and manipulation will prove the separation of the fragments, and generally produce crepitus, though the latter important sign is sometimes not perceived until the broken ends are brought into apposition by extending and drawing back the shoulders. The differences in position of the bone mentioned above will of course produce corresponding modifications of these signs. In transverse fractures, the amount of displacement is often inconsiderable; but pain, loss of power, mobility of the fragments, and crepitus will indicate the nature of the injury.

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* See also the figure at p. 219 in Dr. R. W. Smith's *Treatise on Fractures in the Vicinity of Joints*, &c. Dublin, 1847.

† Malgaigne, *Traité des Fractures et des Luxations*, tome i. p. 468. Paris, 1847.

‡ Lonsdale, *Practical Treatise on Fractures*, p. 208, 1838.

Fracture of the sternal extremity of the clavicle is a very rare accident. Lonsdale,* relating the case of a child three years old, in which the clavicle was fractured about half an inch from the sternum, conjectures that such cases arise from separation of the epiphysis. This, however, clearly cannot be, as the epiphysis at the sternal end of the clavicle is an extremely thin plate of bone, and commencing to ossify at about the age of eighteen, is joined to the bone a few years later; if, then, such an injury could happen, it would be only at this particular period of life. Blandin† describes a case in which the clavicle was fractured between the costo-clavicular and sterno-clavicular ligaments, without displacement; but in the only two specimens of similar fracture that Malgaigne‡ could find in the Musée Dupuytren, the external fragment was displaced considerably downwards and forwards.

Two examples of this accident recently occurred at the Middlesex Hospital. Both patients were girls under ten. In one the fracture, produced by indirect violence, was about half an inch from the sternal joint, and the displacement was very slight; in the other the fracture, caused by direct violence, was a little further from the sternal joint and there was more displacement.

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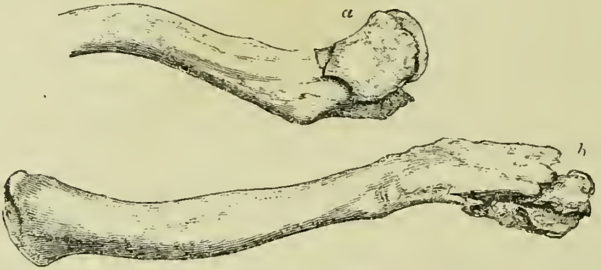
* Op. cit. p. 206.

† *Gazette des Hôpitaux*, 22 avril 1845.

‡ Op. cit. tom. i. p. 491.

Fractures of the acromial extremity of the clavicle are much more frequent than the last. R.W. Smith[*] has shown, from examination of specimens of bones after death, that the outer end of the clavicle may be broken, either between the conoid and trapezoid portions of the coraco-clavicular ligament, or between this ligament and the acromio-clavicular articulation. In the former situation the fracture is of comparatively rare occurrence, and attended with scarcely any displacement of either fragment of the bone; in the latter, on the contrary, there is generally a considerable amount of displacement of the outer fragment; its inner end being drawn upwards and outwards by the action of the clavicular portion of the trapezius muscle, while the outer or articulating surface is directed downwards and inwards by the weight of the arm and the action of the muscles passing from the chest to the shoulder. This displacement is sometimes carried so far that in some of the cases examined, the outer fragment had united to the other at a right angle.[†] The inner fragment is not materially altered in position, unless the coraco-clavicular ligament be ruptured.

FIG. 94.



Extremely oblique fracture of the acromial end of the clavicle. *a*, under surface; *b*, anterior view. From a preparation in the Middlesex Hospital Museum; Cat. No. i. 15, d.

An *incomplete fracture* of the body of the clavicle, sometimes attended with *bending* of the bone, is occasionally met with in children. Vide FRACTURES, p. 43.

Comminuted fractures of the clavicle are not unfrequently the result of direct violence, and are easily recognised by the great mobility of the fragments.

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[*] Op. cit. p. 209.

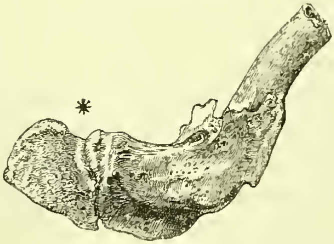
[†] This observation is corroborated by a recent specimen exhibited by Mr. Canton to the Pathological Society, Nov. 6th, 1860.

Compound fractures of the clavicle are extremely rare; and notwithstanding its vicinity to the large vessels and nerves of the neck, serious complications from implication of the soft parts do not often follow fractures of this bone.

Among the severe injuries which occasioned the death of the late Sir Robert Peel, was 'a comminuted fracture of the left clavicle, below which a swelling as large as the hand could cover, and which pulsated synchronously with the contractions of the auricles of the heart, formed.' This was evidently the result of a wound of some large vein, probably the subclavian, by the broken ends of the bone. From the intense pain suffered, it was also conjectured that some of the nerves of the axillary plexus were lacerated.* In the Museum of St. George's Hospital is a specimen in which the fractured end of the bone was driven through the internal jugular vein. The patient, a boy aged thirteen, had been standing under a tree in a storm, and was struck by a falling branch. Several cases are also on record of injury to the brachial plexus of nerves, followed by paralysis of the arm.

Fracture of both clavicles in the same subject sometimes occurs. Malgaigne could only collect five cases. A man, aged forty-seven, was admitted a few years ago into the Middlesex Hospital with ununited fracture of both clavicles, occasioned by the same injury. Want of union is very uncommon; in this case it was probably owing to the difficulty of restraining the motion of both arms at the same time during the treatment; as a general rule, no bone in the body unites more readily. In 1867, a young girl was brought to the Middlesex Hospital with both collar bones and some ribs broken. She was kept flat on her back in bed for some days, and made a good recovery.

FIG. 95.



An extremely oblique comminuted fracture of the acromial end of the clavicle: under surface. The asterisk points to the acromio-clavicular joint. From a preparation in the Middlesex Hospital Museum; Cat. No. i. 15, d.

Treatment.—Although the indications to be followed in the treatment of fractured clavicle are plain enough, the numerous contrivances that have been invented for the purpose, and the diversity of the methods adopted in different countries, and by different surgeons, are sufficient to show the difficulties that are practically found in carrying them out. As Dr. F. H. Hamilton says, 'a catalogue of the names only of the men who have upon this single point exercised their ingenuity, would be formidable, nor would it present any mean array of talent and of practical skill.'

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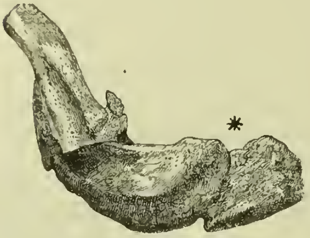
* *Lancet*, July 6th, 1850.

Fig. 96.



The upper surface of the same preparation. The inner fragment overrides, and the outer has been twisted so as to make a considerable angle with it.

The most certain method to insure union without deformity, is to keep the patient lying on the back in bed until the fracture has united, the head being fixed to the pillow, and both arms confined to the side of the body. This plan may be adopted in the case of young ladies who wear low dresses, and in whom it is consequently particularly desirable to preserve the symmetry of the clavicles; but men and boys will seldom be found to submit to the confinement, and it is satisfactory to know that the amount of shortening which almost invariably follows an oblique fracture, treated in the usual way, will rarely interfere in any appreciable degree with the perfect use of the arm.

Presuming that the ordinary displacement has occurred, to restore the outer fragment to its normal position, the shoulder must be drawn outwards, upwards, and backwards. For a description of the many, more or less complicated, forms of apparatus invented to retain the parts in this position, the reader is referred to special treatises upon the subject, as they have nearly all met with but a very limited or local application, and without figures any account of them would be unintelligible. As the results of the method of treatment generally followed at most of the hospitals in London are as satisfactory as those attributed to any of the others, and as there is in it the great advantage of requiring no other materials than those which are at all times at the command of the surgeon, I shall content myself with describing it. A stout wedge-shaped pad, with the broad end upwards, stuffed with tow or horse-hair, and having a little cotton-wool wrapped around it, is placed well up in the axilla. Then the elbow is brought close to the side, and the fore-arm laid across the front of the chest, the hand being raised towards the opposite shoulder. It is now to be firmly bound in this position with a broad calico roller, some of the turns of which are made to pass beneath the elbow and over the opposite shoulder, so as to act as a sling, and raise the humerus. The bandages should be secured by a few stitches.* Some surgeons advance the elbow, others think that it should be directed somewhat backwards, but an intermediate position is more generally preferred. Very frequently, before the elbow is fixed, a figure-of-eight bandage is placed round the shoulders, and tied tightly behind, with the intention of drawing backwards the extremity of the clavicle; but this is by many, and with much justice, objected to, on the ground that, unless put on with very great care, it may press upon the inner end of the distal fragment and push it behind and below the other, thus adding to the deformity which it is intended to prevent. The axillary pad, which was introduced by Desault as a fulcrum by which the clavicle may be extended when the elbow is pressed to the side, is now generally used of smaller size than was originally proposed, and is discarded altogether by some surgeons, on account of its liability to compress the axillary vessels and nerves. The apparatus is then reduced to little more than a sling for the elbow.

It is evident from these differences of opinion, that in the management of fractured clavicle, as in that of any other similar injury, no one rule ought to be followed. Careful attention to the peculiarities of the individual case will alone suggest the particulars of the treatment that should be adopted; and whatever may be the apparatus determined upon, it should be frequently examined, in order to be sure that the intention with which it is applied is really being carried out, and that no parts of it have become loose or disarranged, or, on the other hand, are unnecessarily tight, so as to give pain or chafe the skin.

If the fracture is attended with complications, or if both clavicles are broken, it is advisable to confine the patient to bed.

Union usually takes place in about three weeks—in young subjects even earlier.

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* Bandages stiffened with starch, dextrine, or plaster of Paris are often used with great advantage.

Fractures of the Scapula.

As this bone is not, like the clavicle or other long bones of the arm, placed between resisting points, it is not often affected by any application of indirect violence; and as its peculiar conformation and protected situation afford it considerable immunity from direct injury, it is very rarely broken. The statistics of the Middlesex Hospital for sixteen years (table p. 764) give 1·07 per cent as the relative frequency of fractures of the scapula, which agrees closely with that given by Gurlt. The shape of the scapula is so very irregular, that fractures occurring in its different parts present special characters, and require therefore separate consideration.

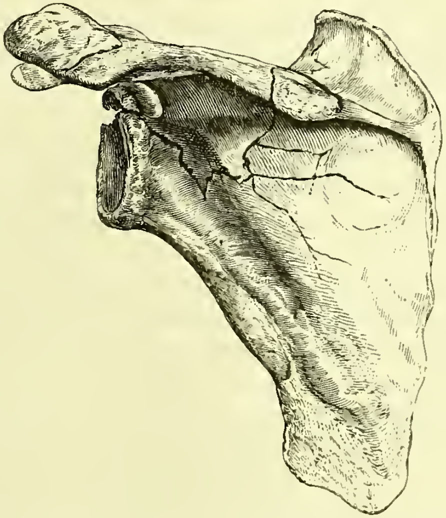
1. *Fracture of the body of the scapula* may occur in combination with other injuries when the trunk is severely crushed, as by the fall of a heavy weight upon it. It has also been caused by a blow applied directly, the passage of a cart-wheel over it, or a fall backwards, in which the bone is struck against some hard substance, such as the corner of a table.

The fracture usually runs transversely or obliquely across the flat part of the body of the bone beneath the spine; but sometimes it extends vertically through the spine, or the bone, which in other instances is variously starred or comminuted. An incomplete fracture through the spine alone, or one of the margins, appears to be sometimes met with; and occasionally the thin central portion of the infra-spinous fossa is fissured, or even deeply indented, while the borders, being thicker and stronger, have escaped injury. There is often but little displacement of the fragments; sometimes, however, one or the other of the broken edges may be felt to project. In a man aged forty-three, lately a patient at the Middlesex Hospital, the body of the scapula was broken by a carriage-wheel passing over his back; he was so extremely thin, that the nature of the injury could be ascertained with perfect facility. The line of fracture extended from the anterior costa, one inch above the inferior angle, upwards and backwards to the posterior costa, just below the root of the spine. The triangular portion thus separated was drawn directly upwards under the other, and became united there; so that the scapula was eventually one inch shorter than the other, and had the lower end deeply notched.

There is a specimen in Guy's Hospital Museum* in which the line of fracture is almost the same, but the inferior fragment has united on the dorsal surface of the other. The different direction of the displacement of the fragment in these instances was probably communicated to it at the moment when the injury was inflicted, while the drawing upwards was due to the combined action of the muscles attached to it.

Mobility can generally be detected by grasping the shoulder and upper part of the scapula with one hand, and the lower part of the bone near the inferior angle with the other; crepitus will also be obtained in this manner, or by placing the hand flat upon the dorsum of the scapula, and moving the humerus in various directions. But great care must be taken not to mistake that pseudo-crepitus which appears to be caused by the movement of the tendons over the shoulder-joint for a bony crepitus; a mistake not unfrequently made by inexperienced surgeons when examining injuries about the shoulder. In muscular and fat subjects, and where there is little displacement, the diagnosis of these fractures is often attended with difficulty,

FIG. 97.



Fracture through the glenoid cavity, running into the body, and crossing the spine of the scapula; with fracture of the acromion process. From a preparation in the Middlesex Hospital Museum; Catalogue i. 17. No history is attached.

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[*] No. 1,097,^{70}.

but in others the signs are sufficiently obvious. Malgaigne recommends that in making the examination, the fore-arm should be brought behind the back, and the hand raised as much as possible, as by these means the inner border of the scapula will be rendered prominent.

Treatment.—The fragments having been reduced as completely as possible by manipulation, the body of the scapula should be confined by a shield of gutta-percha modelled to it, or with a broad bandage or strip of adhesive plaster. The motions of the arm are then to be restrained and the elbow raised, by supporting it in a sling. When there is much displacement, it is difficult to keep the fragments in good apposition by the application of compresses, or any of the other contrivances that have been suggested for the purpose; but in most cases union takes place readily, and although there may be some deformity, the arm regains its proper motions.

2. *Fracture of the acromion process.*—The acromion process being the most prominent part of the shoulder, it is liable to be broken across when a blow is received directly from above, in falls upon the shoulder, and also perhaps by upward pressure of the head of the humerus, in falls on the elbow or hand. The frequency of this accident has been overrated, as many of the numerous specimens found in museums of what appear at first sight to be old ununited fractures of the acromion, are probably examples of non-union of the epiphysis.* There seems to be some as yet unexplained connection between this condition and the disease called chronic rheumatic arthritis of the shoulder-joint, as they are often found associated.† For this reason, little dependence can be placed upon the statement, founded on the examination of such specimens, that after fractured acromion the union is always of a ligamentous character.

The fracture usually extends directly across the process, separating a larger or smaller portion from the rest of the bone. Sometimes it is only the extreme tip beyond the clavicular articulation which is broken off. Occasionally there is no displacement, the detached fragment being held in its place by the periosteum, but generally it is drawn downwards and a little forwards, by the action of the deltoid and weight of the arm.

The symptoms are, pain in the injured part, with loss of power in moving the arm, especially upwards. The shoulder has lost somewhat its rounded form, its extremity being sunk. On passing the finger along the spine of the scapula towards the acromion, a sudden depression is felt at the seat of fracture, and mobility of the process itself can be perceived. On raising the arm so as to bring the fragments in apposition, all the abnormal appearances are lost, and crepitus, which is absent as long as the arm hangs down, can now be obtained.

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* F. H. Hamilton, op. cit. p. 211.

† R. Adams, op. cit. p. 107.

Treatment.—The principal indication is to support the elbow, so that the acromion may be raised by the head of the humerus; this is accomplished by a sling, which must be made to give more support to the elbow than to the fore-arm, allowing the hand to drop. More perfect apposition can be obtained if a pad be placed between the side and the elbow, so as to keep the latter away from the body, and inclined a little backwards. The arm should then be fixed by a roller passed round the chest, and kept in this position for about four weeks.

3. *Fracture of the coracoid process* is an extremely rare accident, and only produced by severe direct violence; it is usually accompanied by other injuries, as dislocation of the humerus in the cases reported by South* and Holmes,† or by fracture of other parts of the scapula. If the coracoid process alone is broken off, the three muscles attached to its extremity would tend to draw it downwards and inwards; but while the strong coraco-clavicular ligaments remain entire, the displacement cannot be very great. In an uncomplicated case, there is no alteration in the shape of the shoulder, the principal diagnostic signs being crepitus and the mobility of the fragment, discovered by manipulation.

Two cases of fracture of this process have come under my own notice. In both, the fracture was caused by a fall forward from a slight height with the arms stretched forward; there was mobility of the tip of the process, with crepitus and pain, but not any displacement.

The treatment consists in supporting the arm in a sling, with the elbow advanced upon the front of the chest, so as to keep the muscles inserted into the process relaxed, and as much at rest as possible.

4. *Fractures of the neck of the scapula, and of the glenoid fossa.*—It is the opinion of most modern writers on surgery, that simple fracture across the anatomical neck of the scapula never occurs.

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* *Med.-Chir. Trans.* vol. xxii. p. 100.

† Ibid. vol. xli. p. 447.

There is no specimen exhibiting it in any of the museums in London, and Hamilton says that he has not been able to find one in any of the American cabinets. There are several cases on record of fracture through what has been called the surgical neck, *i.e.* the narrow part of the bone, opposite the notch in the superior costa, the coracoid process being included in the separated portion. In all of those with which I am acquainted, there has been also a general comminution of the body of the bone. One specimen is in the Museum of Guy's Hospital;* another in which repair has taken place, in the Museum of the Royal College of Surgeons; and the well-known case reported by Du Verney,† where the injury was occasioned by a fall into a stone quarry, forms a third example. The three cases related by Sir Astley Cooper, and various others, which have appeared more recently in the journals, of 'fracture of the neck of the scapula,' were founded only on diagnosis made during life. They are, therefore, not entirely to be relied upon, especially as it has been shown by Malgaigne that most of the symptoms usually assigned to this injury might be produced by a dislocation of the humerus into the axilla, with fracture of a portion of the margin of the glenoid fossa.

The last-named accident is not very uncommon; the inner border is more frequently the seat of injury, but fractures have been found running across the glenoid fossa, and even splitting it up into several portions. In a case which I believed to be one of this kind, admitted June 25, 1860, into the Middlesex Hospital, there was a distinct bony crepitus accompanying subcoracoid dislocation of the humerus. The latter when reduced almost immediately reappeared, and as the spasm of the muscles by which this was occasioned increased after every reduction, it constantly became more difficult both to replace the bone, and when replaced to keep it in position. The patient was then brought completely under the influence of chloroform, a large pad fixed in the axilla, and the elbow bound close to the side and raised. By these means the humerus was retained perfectly in place, and no subsequent difficulty was experienced during the treatment. At the end of three weeks the bandages were removed, and passive motion commenced in the joint.

Fractures of the Humerus.

The fractures to which this bone is liable may be conveniently divided into three groups, viz. (A) those affecting the upper extremity, or that part which is situated above the surgical neck of the bone; (B) those of the shaft; and (C) those of the lower articular extremity.

The injuries belonging to the first group, although of less frequent occurrence than either of the others, demand the fullest attention of the surgeon, as they present considerable difficulties both of diagnosis and treatment. In the following account of them, I have availed myself largely of the valuable essay upon the subject by Dr. R. W. Smith, of Dublin.‡

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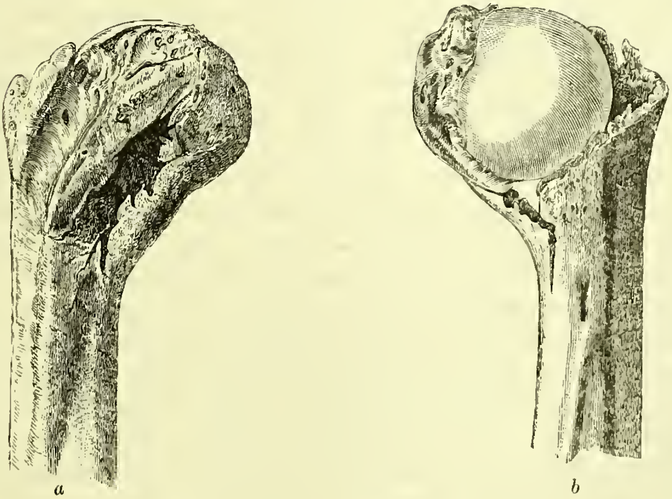
* No. 1,097,^{85}.

† *Traité des Maladies des Os*, 1751, tom. i. p. 227.

‡ Op. cit. chap. iv. p. 176.

A. *Fractures of the upper end of the humerus* are usually produced by direct violence, as severe blows, or more frequently falls, in which the shoulder comes in direct and violent contact with the ground or some hard substance. Sometimes, however, they appear to have been caused by falls upon the elbow or hand. The point at which the fracture occurs may be (1) the anatomical neck of the bone; (2) the line of junction of the epiphysis with the shaft, *i.e.* immediately below the tuberosities; or (3) a little lower down, at that part of the bone called the surgical neck. A fourth form of fracture in this neighbourhood is the separation of the greater tuberosity from the remainder of the bone. As the capsular ligament of the scapulo-humeral articulation is attached just below the anatomical neck, the first of these fractures is intracapsular; the others are all extracapsular; an important distinction, both as regards their symptoms and prognosis.

FIG. 98.



Fracture through the anatomical neck of the humerus. From a preparation in the Museum of the Royal College of Surgeons; Catalogue No. 2,933. *a* anterior, *b* posterior view. 'The shaft is drawn forwards, upwards, and inwards; the outer surface of its upper end is united by bridges of bone to the broken surface of the head and neck, and the anterior fourth of the head rests in a cavity on the top of the shaft.' The patient was a woman aged seventy-seven.

1. *Fracture at the anatomical neck of the humerus.*—A glance at the form of this part of the bone will be sufficient to show that fracture here must be a rare accident; yet sufficiently numerous

specimens are to be found in museums, and post-mortem examinations are on record to establish the claims of this injury to a place in surgical pathology. Displacement of the separated fragment cannot be caused by the action of muscles, as none are inserted into it; but not unfrequently, from the violence with which the shaft is driven against it, the head, lying loose in the capsule of the joint, slips off the shallow glenoid fossa, is forced through the capsule into the axilla, or sometimes is even turned completely round, so that the cartilaginous surface is in contact with the fractured end of the lower fragment. Cases are recorded in which it has united in this, and other almost equally remarkable positions.*

If the head of the humerus be completely separated, we might expect that it would remain as a foreign body in the joint, and then perish from want of nutrition, and be eliminated by suppurative action, unless previously removed by operation; but Gurlt has been unable to find a single authenticated instance of simple fracture of the anatomical neck where the completely separated head of the humerus had become a sequestrum and had been thrown out.† Ligamentous and even osseous union has been met with in some cases; but in these the separation has probably not been entire, portions of the capsule attached to the upper fragment have maintained its vitality. The reparative action is, as might be supposed, chiefly accomplished by the lower fragment, which often throws out bony spicula to such an extent as to form a complete cup surrounding the head‡. It not unfrequently happens that the head of the bone is impacted in the cancellated structure of the thick upper end of the humerus, between the tuberosities. This condition is far more favourable for osseous union than the former, though of course it must occasion some permanent deformity of the joint.

The signs of fracture of the anatomical neck without impaction are not very obvious, unless the head of the bone be much displaced; in fact, pain at the seat of injury, some impairment of motion, and crepitus, with absence of the characteristic signs of other fractures in this neighbourhood, are the only evidences to be depended on. In impacted intracapsular fracture, according to R. W. Smith, 'the arm is slightly shortened, the acromion process projects more than natural, and the shoulder has lost to a certain extent its rounded form, the upper extremity of the shaft of the humerus is approximated to the acromion, and the entire of the globular head of the bone cannot be felt. In consequence of the fracture of the tuberosity (which often accompanies impaction of the head of the bone), crepitus can be readily detected, when the shoulder is grasped with moderate firmness and the arm rotated.'

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* R. W. Smith, op. cit. p. 194; Malgaigne, op. cit. tome i. p. 529; Sir A. Cooper, *Treatise on Dislocations and on Fractures of the Joints,* edited by Bransby Cooper, 1842, p. 417.

† *Handbuch der Lehre von der Knochenbrüchen,* Th. 2, p. 745.

‡ Sir A. Cooper, op. cit. p. 428; R. W. Smith, op. cit. p. 190.

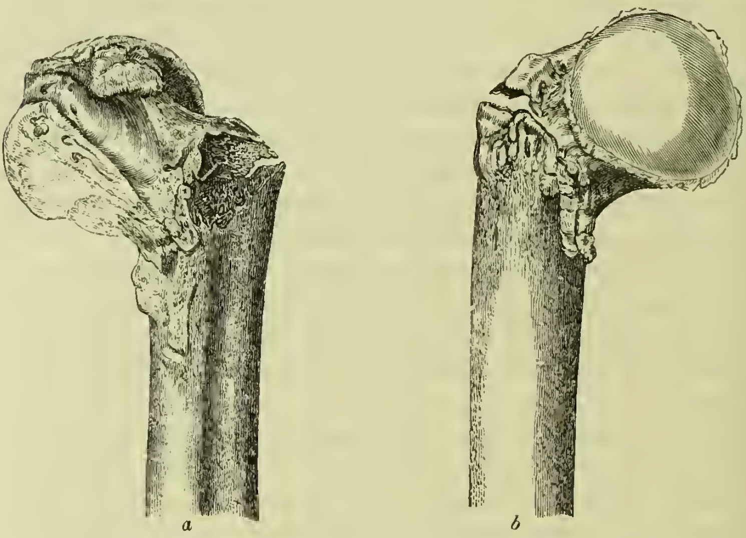
2. *Fracture at the line of junction of the epiphysis.*—As the large epiphysis at the upper end of the humerus, which includes the head and the two tuberosities, is usually united with the remainder of the bone at the age of twenty, it is only in youth or early manhood that we can expect to meet with this injury. At these periods its occurrence is not unfrequent. The upper fragment remains in the glenoid cavity, the superior end of the lower one is drawn inwards by the action of the muscles passing from the chest to the humerus, forming a marked projection situated beneath the coracoid process; but, owing to the breadth of the bone at this part, it is almost impossible that the two broken surfaces should leave each other so completely as to cause any riding, and consequent diminution in the length of the arm.

The following are the signs presented by this injury: the axis of the humerus is directed upwards, inwards, and forwards; the elbow, however, projects but little from the side; the head of the bone can be distinctly felt in the glenoid cavity, and it remains motionless when the shaft is rotated. The projection above spoken of, formed by the upper end of the diaphysis, does not present the sharp irregular margin of an ordinary fracture; on the contrary, it feels rounded, and its superior surface is smooth and slightly convex. 'By pressing this part outwards, and directing the elbow inwards during extension and counter-extension, crepitus can be perceived, and the deformity removed without much difficulty; but the moment the parts are abandoned to the uncontrolled action of the muscles, the deformity recurs.' (Smith.) The same author observes, that 'there is no fracture incidental to the upper end of the humerus in which it is more difficult to maintain the fragments in their proper relative position.'

3. *Fracture of the surgical neck of the humerus.*—This is the most common of all the fractures in this region. The part of

the bone implicated is that between the tuberosities, and the insertion of the pectoralis major and latissimus dorsi muscles. The line of fracture is generally transverse, but it may be oblique. The amount of displacement of the fragments varies considerably. In characteristic examples the upper fragment is tilted upwards and outwards by the action of the muscles inserted into the great tuberosity, the lower fragment is drawn inwards towards the axilla, by those inserted into the bicipital groove, while the various muscles which pass from the scapula to the humerus tend to draw it upwards, an effect which will be greatly facilitated if the line of fracture is oblique. The upper end of the lower fragment has occasionally been observed to project anteriorly, externally, and even posteriorly *—differences depending probably upon the direction of the line of fracture, and also upon the direction from which the violence causing the injury proceeded. Impaction of the broken ends frequently

Fig. 99.



Fracture through the surgical neck of the humerus. *a* front, *b* back view. The preparation in the Museum of the Royal College of Surgeons was removed from the body of a woman aged seventy-nine. 'There is considerable displacement . . . the upper part of the shaft being drawn forwards, and its lower end turned backwards and outwards. Union by ligament took place, and some new bone is formed around the ends of the fractured part.' The patient recovered considerable power in the arm; she could make all the usual underhand movements, but could not raise the shoulder or upper arm. Catalogue No. 2,934.

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[*] Malgaigne, op. cit. tome i. p. 516.

occurs, in which case (contrary to what obtains in fracture of the anatomical neck) the lower fragment usually penetrates into the cancellous structure of the superior.

In impacted fracture there is very little alteration in the form of the limb, and the signs are remarkably obscure, and chiefly of a negative character. The usual signs accompanying non-impacted fracture are as follows. There is no flattening beneath the acromion, the head of the bone remaining in the glenoid cavity, where it can be felt lying motionless when the arm is rotated; the prominence caused by the upper end of the lower fragment can also be readily detected. This is rendered more distinct, and is felt to move with the rest of the bone, when the elbow is pushed up and rotated; the mobility of the shaft of the humerus is very free, and crepitus distinct, when extension is made. There is usually much pain shooting down the fingers, from the irritation of the axillary plexus of nerves, increased, of course, by all attempts at motion.

Treatment of fractures of the neck of the humerus.—The treatment is the same in principle for all the above fractures; its details will be guided, to a great extent, by the amount and nature of the displacement.

If impaction has occurred, it is very undesirable to disengage the ends of the bone, as this condition greatly facilitates union, especially in the intracapsular variety. The arm should merely be bandaged to the side, the fore-arm supported in a sling, the swelling and inflammation reduced by the application of cold lotions; and, as R. W. Smith observes, 'the prudent surgeon will never omit to announce to the patient, that a certain degree of impairment of the motions of the joint will be a permanent result of the injury.'

In the ordinary fracture of the surgical neck, the method usually followed (almost the same as that described by Sir A. Cooper) is, to place a pad in the axilla to act upon the upper end of the shaft, with small straight wooden splints behind and in front, or a single one on the outside of the arm; to bandage the elbow to the side; and to support the hand in a sling, letting the elbow hang, so that the weight of the arm may tend to overcome the action of the muscles which raise the lower fragment. A gutta-percha cap, moulded to the shoulder, and extending down the outside of the arm nearly to the elbow, is a convenient substitute for the splints. Another plan, recommended by Erichsen,* answers well in some cases: a leather splint, about two feet long by six inches broad, is bent upon itself in the middle, so that one half of it may be applied lengthwise to the chest, and the other half to the inside of the injured arm; the angle formed by the bend, which should be somewhat rounded and well padded, being pressed up into the axilla.

Passive motion should be employed as soon as union is effected, which, according to Sir A. Cooper, is in about one month in youth, but requires from two months to twenty weeks in old age. Malgaigne allows from thirty to thirty-five days as the period at which passive motion should be commenced, in ordinary cases. The same author also gives the important advice, that the elbow, wrist, and finger-joints should be kept in exercise throughout the treatment, as by this means some of the stiffness, which always follows the confinement and want of use of these articulations, will be obviated.

4. *Fracture of the greater tuberosity* is not at all uncommon in connection with dislocation of the head of the humerus forwards, when the detached process is either drawn backwards by the action of the three muscles inserted into it, and lies in the glenoid fossa of the scapula, or is retained in connection with the humerus by unbroken portions of the periosteum or capsular ligament.†

This fracture has been said to occur alone, being caused either by direct violence, or sudden action of the posterior scapular muscles. R. W. Smith has given a detailed account of the symptoms and pathology of this accident, as observed in two cases, in one of which a post-mortem examination was obtained. In both of these, however, there appears to me to have been an actual dislocation of the head of the humerus, beneath the coracoid process, which must be looked upon as the primary abnormal condition, and the fracture of the tuberosity only as a concurrent circumstance; unless, indeed, it could be supposed that the action of the subscapularis muscle, when deprived of its usual antagonists, could be sufficient to displace the humerus to the extent indicated.‡

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* *Science and Art of Surgery*, 3rd edit. p. 231.

† See page 814.

‡ Malgaigne does not recognise 'fracture of the greater tuberosity' as a distinct injury, and cites Smith's cases as examples of true 'intracoracoid' luxation of the humerus. Op. cit. tome ii. p. 518.

B. *Fractures of the shaft of the humerus.*—The humerus is broken very much more frequently in some part of its shaft than in either extremity; the seat of the fracture being more often below than above the middle of the bone.

The common causes are either direct violence or falls on the hand or elbow. Many well-authenticated cases are on record in which it has been produced by muscular action alone. These cases have generally occurred in the act of throwing a stone or ball, striking a blow, suddenly seizing some support while falling, or in a practice formerly frequent, of trying the strength of the arm, in which two men rest the elbows on a table, place the palms of the hands in contact, and each endeavours to press his adversary's hand down.

A case of this kind was described, as long ago as 1791, by Debeaumarchef: and Lonsdale reports two as occurring under his own observation at the Middlesex Hospital. Numerous examples of fracture of the humerus from muscular action are collected by Malgaigne;* and others have appeared more recently in the journals.† In some of these there probably existed a previous condition of the bone which rendered it particularly susceptible to fracture; but in most of them there seems no reason to suspect that it was otherwise than perfectly healthy.

The line of fracture is usually transverse, but it may be oblique. In the latter case it may pass in any direction, though perhaps most often from above, downwards and outwards. Transverse fractures are usually attended with little or no displacement; when oblique, the position of the fractured extremities is determined by the direction of the line of fracture. The principal effect of muscular action is to approximate the extremities of the bone, and thus produce riding of the fragments and shortening of the limb. The deltoid, however, tends to tilt upwards and outwards that part of the humerus into which it is inserted: hence surgical writers frequently make a distinction between the fractures above, and those below, the insertion of this muscle; in the former, the fractured end of the upper fragment inclines inwards, and that of the lower, outwards; in the latter, the end of the upper fragment projects outwards, and the lower inwards—a distinction, however, of not much practical importance. Shortening of the limb does not generally take place to any great extent, as the actions of the muscles have a counterpoise in the weight of the lower part of the arm.

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* Op. cit. tome i. pp. 531 et seq.

† See *Medical Times and Gazette,* 1857, 2nd vol. pp. 85 and 254.

The signs of fracture of the shaft of the humerus are obvious, and the diagnosis is unattended with difficulty. There is pain, loss of power in the arm, and usually some deformity; and as the two portions can easily be grasped separately, their mobility is readily ascertained, and crepitus produced. Simple fractures without displacement generally unite favourably; yet, according to the commonly received opinion, there is no bone so subject to ununited fracture, and the formation of false joint, as the humerus. The statistical tables drawn out by Norris show an equal liability in the femur.* Twenty-five to thirty days are usually required to effect consolidation in young subjects, and thirty-five to forty in adults. (Malgaigne.)

Treatment.—In ordinary cases, after the fractured ends are brought into apposition, by extension, if necessary, four small, straight, well-padded wooden splints should be applied, one on each side of the humerus; the elbow bent at a right angle, and allowed to hang down, while the hand is supported in a sling. The splints should be so narrow as not to overlap each other, and must be confined in their place by straps and buckles, or broad strips of adhesive plaster. The starched bandage or gutta-percha will often be found a useful substitute. If the fracture is very oblique, and attended with much displacement from muscular action, although the weight of the arm aids us somewhat, some further permanent extension is frequently required, in order to avoid deformity of the limb. Much may be done by careful management of the splints and pads, arranging them so as to press the projecting parts into place; something also may be accomplished in the way of extension by the splint on the inside of the arm (the top of which is well padded) being made to press into the axilla on the one hand, and against the upper edge of the inner condyle on the other; this plan, however, must be regulated with care, otherwise the pressure of the upper end upon the axillary veins is apt to cause the arm to swell. Unfortunately all the mechanical contrivances which have hitherto been invented for the purpose of effecting extension, are more or less open to objections, and have fallen into disuse almost as soon as they have been made public.

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* See FRACTURES, p. 79.

C. *Fractures of the lower end of the humerus.*—While fractures of the shaft of the humerus are met with in not very dissimilar proportions in both sexes, and at all ages, those of the class now under consideration occur chiefly among young men and boys, with whom also dislocations at the elbow-joint are most frequent.

The fractures of this part of the bone may be divided, as in the upper end, into those that are external to the joint, and those which implicate the synovial membrane. To the first class belong, fracture of the humerus just above the condyles; separation of the lower epiphysis; and fracture of the projecting point of the internal condyle (called by the French the 'epitrochlea,' by Hamilton 'internal epicondyle'). In the second division are, transverse fracture of the lower end of the humerus with a vertical fissure extending through the lower fragment, so that the condyles are separated both from each other and from the shaft; and an oblique fracture separating one or other of the condyles, with a contiguous portion of the articular surface, from the rest of the bone.

1. *Fracture across the shaft of the humerus at its lower end* ('*fracture sus-condylienne,*' Malgaigne), immediately above the condyles, where it is expanded laterally, and is very thin in the antero-posterior direction, is not an uncommon accident at any age, although in childhood and youth a separation of the lower articular epiphysis will be more likely to occur under the circumstances which would occasion this injury. The most common cause of this, as well as of all the other fractures in this situation, is a fall upon the elbow while bent. The line of fracture is sometimes transverse, though more often oblique from before upwards; but it may run in the reverse direction, or even slant laterally.

The nature and amount of deformity are determined by the direction of the line of fracture, and also sometimes by the mode in which the injury is inflicted. The powerful action of the muscles passing from the upper arm to the fore-arm usually causes a great tendency to shortening and riding of the fragments. In most cases the lower one is drawn backwards and upwards by the triceps, producing an appearance similar to that caused by dislocation of both bones of the fore-arm backwards. The olecranon projects unnaturally, there is a hollow above it, and corresponding to this in front of the arm, a prominence formed by the lower end of the shaft of the humerus. The motions of the elbow and fore-arm are more or less impaired, though there is not that absolute immobility that is met with in dislocation. As a mode of distinction between this fracture and dislocation of the fore-arm, Sir A. Cooper gives 'the removal of all marks of dislocation on extension, and their return as soon as extension is discontinued,' as well as the crepitus detected on rotating the fore-arm upon the elbow; but as fracture of the coronoid process might produce signs similar to these, the following diagnostic characters, dependent upon the fact of the condyles and articular portion of the humerus being displaced with the bones of the fore-arm, are important: 'The projection of the olecranon posteriorly is not more distant from the condyles of the humerus than in the natural condition, if there is fracture, but it is much more so in dislocation; also in fracture the anterior projection is not so broad and rounded, and is *above* the fold of the elbow, while in luxation it is much below it. It may be added that, in measuring the arm from the acromion to the prominence of the internal condyle, a shortening will be found in fracture which does not exist in luxation' (Malgaigne).

Treatment.—Extension made by grasping the humerus with one hand, and the fore-arm with the other, will in general suffice to bring the fragments into proper apposition. To retain them so, the elbow should be fixed at a right angle on a jointed wooden splint, or, what is more convenient, a gutta-percha splint moulded to the parts while they are in good position, and extending along the posterior surface of the upper arm, behind the elbow, and under the fore-arm and hand, so as to give good support to the latter. In addition to this, a small straight wooden splint should be fixed in front of the arm, its lower extremity resting on a pad placed over the projecting end of the shaft of the humerus, and firmly strapped to the larger splint. This arrangement may of course be varied, according to the inclination of the displacement of the fractured portions of bone. Passive motion should be commenced in about three weeks, otherwise the elbow-joint will become rigid.

A larger or smaller portion of the *inner condyle* (*epitrochlea*) may be broken off without implicating the articular end of the bone. Attention was first directed to this injury by Granger.* It may be occasioned by muscular action, or more commonly by direct falls upon the inner side of the elbow. The detached portion is usually drawn somewhat downwards by the action of the muscles arising from it. Impairment of the motion of the limb, the mobility of the fragment, and the crepitus, will suffice to distinguish the nature of the accident, unless the swelling is very great. A complication sometimes arises from injury to the ulnar nerve. In the treatment, the elbow, as well as the wrist and fingers, should be semiflexed, so as to relax the muscles which arise from the inner condyle. The injured fragment can seldom be retained perfectly in place; but though some deformity may remain, the movements of the elbow are generally but little interfered with. Passive motion should be resorted to early.

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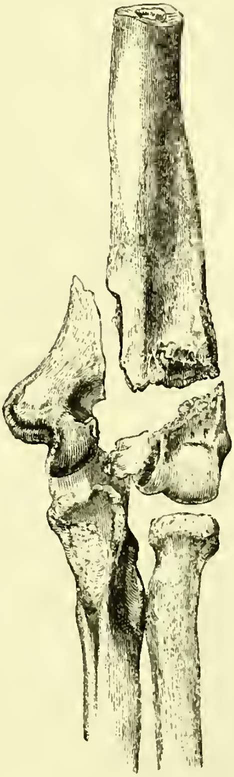
* *Edin. Med. and Surg. Journal*, vol. xiv. p. 196.

2. The remaining fractures of the lower end of the humerus are of a more serious character, as they are necessarily attended with more or less inflammation of the joint, and are consequently almost always followed by some permanent impairment in the movements of the elbow. If the great swelling which frequently comes on after these injuries should mask the nature of the fracture, it will be best to keep the arm at rest, laying it on a pillow, if the patient can be kept in bed, or lightly confined by an angular splint, and treated with evaporating lotions, and other antiphlogistic measures, as the case may demand, until, by the subsidence of the inflammatory action and swelling, the exact seat of the injury will become apparent.

Fig. 100.



Comminuted fracture of the lower end of the humerus, extending into the elbow-joint. From a preparation in the Middlesex Hospital Museum; Catalogue, No. i. 23, d. The patient, a man, aged forty, fell from a considerable height, and sustained this and other serious injuries, which proved fatal.

The symptoms of the first-named of these injuries resemble those of a fracture across the lower end of the shaft of the humerus. The separation of the condyles from each other may be ascertained by grasping and moving them backwards and forwards, when, unless the swelling and effusion into the joint are very great, crepitus will be obtained.

A single fracture, extending obliquely from either the outer or inner side of the humerus, just above the condylar projection, downwards into the joint, and displacing more or less of the articular surface of the bone with the condyle, is commonly spoken of as *fracture of the outer* or *inner condyle*, as the case may be. Of these, according to Malgaigne, the former is most common; but my experience decidedly leads me to agree with South* and others, that the latter is most frequently met with.

The amount of displacement depends upon the size of the piece broken off, and the continuity of its ligamentous connections. If these remain tolerably intact, scarcely any deformity ensues. The best diagnostic sign is obtained by grasping the projection of the injured condyle between the finger and thumb, when it will be found to move separately from the rest of the bone; crepitus will also be usually produced in this way, as well as by rotating the radius, if it be the external, or by flexing and extending the ulna, if it be the internal condyle.

In the *treatment* of the above injuries, the elbow should be bent at a right angle, and fixed by a jointed wooden splint, or the gutta-percha apparatus recommended above for fractures of the lower end of the shaft of the humerus. Sir A. Cooper advises that passive motion should be commenced at the expiration of three weeks after the accident in the child, and at a month in the adult. This practice has been followed by most English surgeons. Malgaigne begins to move the joint on the twentieth day. The following rules, given by Dr. F. H. Hamilton, deserve consideration: 'Within seven days, and perhaps earlier, passive motion must be commenced, and perseveringly employed from day to day, until the cure is accomplished; indeed, in a majority of cases, it is better not to resume the use of splints after this period; for although at this time no bony union has taken place, yet the effusions have somewhat steadied the fragments, and the danger of displacement is lessened, while the prevention of anchylosis demands very early and continued motion.'†

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* Translation of Chelius's *Surgery*, vol. i. p. 557.

† Op. cit. p. 262.

A very severe crush, such as might be occasioned by the passage of a heavy body over the joint, may produce even greater complication of fracture than any of the above, but this is uncommon unless there be an external wound also. For the treatment of compound fractures of the elbow-joint, see p. 761.

Fractures of the Bones of the Fore-arm.

A. *In the vicinity of the elbow-joint.*—1. *Fracture of the olecranon.*—This injury is much more frequently met with in men than in women, and principally during middle life. Before the age of fifteen it is almost unknown. In the table at p. 764, its relative frequency is 3·17 per cent. It is generally caused by a fall upon the back of the elbow when bent, or by a direct blow; but a sudden contraction of the triceps muscle has been said to produce it. The portion that is separated varies in extent, from a mere shell of bone to the whole of the process. The fragment may be retained in its place by its strong ligamentous connections and periosteum, but it is more frequently drawn away from the remainder of the bone by the action of the triceps, to the extent of from half an inch to an inch and a half; the interval being increased when the arm is bent. The power of motion in the arm, especially of extension, is very much impaired. If the fragment is separated, the diagnosis is usually made without difficulty. On tracing the subcutaneous border of the ulna backwards, a distinct depression is felt at the elbow, above which the detached olecranon, easily movable from side to side, can be felt. Crepitus cannot be produced unless, on extending the fore-arm, the fractured surfaces can be brought into contact with one another.

The fragment unites usually by ligament only; but perfect osseous union does occasionally occur, of which we have proof in a case reported by Mr. F. D. Fletcher, of a boy aged sixteen, who fractured both olecranons, and whose death ten months afterwards afforded an opportunity of examining the state of the injured parts. The displacement had not been very great.*

Treatment.—The main indication is to keep the triceps relaxed; the next, to endeavour by mechanical means to maintain the detached portion in its normal situation. To effect the former, the arm is to be kept extended. The flexed position of the elbow, used in all other fractures about the joint, is quite inadmissible in fractures of the olecranon. Generally, a straight wooden splint, well padded, is fixed along the front of the arm; but gutta-percha not only has the advantage of accurately adapting itself to all the inequalities in the form of the limb, but also, owing to its possessing a slight degree of elasticity, is more comfortable. It should extend from the upper part of the arm to the wrist, and be fixed by two or three bands of adhesive plaster. To fulfil the second indication, which is only necessary when the displacement is great, a roller should be placed upon the arm, from the fingers upwards, and where it comes to the elbow, it may be made, by a figure-of-eight arrangement, to press the top of the olecranon downwards. Sir A. Cooper recommends that a piece of linen bandage be placed longitudinally on each side of the joint; over these, wetted rollers are to be applied round the arm, one above and another below the elbow; the extremities of the linen are then to be doubled down over the rollers, and tightly tied, so as to cause their approximation. In a month the splint should be removed, and passive motion commenced, but with great caution, as bending the elbow necessarily puts the newly-united part on the stretch.

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* *Medical Times and Gazette,* 1851, vol. ii. p. 173.

As this fracture usually extends into the joint, and is in most cases occasioned by direct violence, some inflammation of the synovial membrane will necessarily take place. Too great action should, however, be guarded against, by the usual antiphlogistic treatment; and if it proceeds to such an extent as to threaten anchylosis, the extended condition of the arm should be relaxed, so that the elbow may become fixed in the position most convenient and useful to the patient.

2. *Fracture of the coronoid process of the ulna* is said to occur in connection with dislocation of the radius and ulna backwards, and also to be sometimes met with without that complication.

The cases that have been reported in which it has been observed in the living subject are all more or less unsatisfactory, and have differed considerably in the symptoms which they presented. I have been able to meet with but three or four specimens and recorded post-mortem examinations of this injury; one of the former is in the Museum of Guy's Hospital.* Another case is that of a man killed by a fall from the roof of St. George's Hospital, in whom the coronoid processes were found to be fractured, and the two bones of the fore-arm dislocated backwards on both sides. The specimens are now preserved in the Museum of the hospital.* Dr. F. H. Hamilton, after a careful analysis of all the published cases, arrives at the conclusion that this injury is extremely rare.†

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* No. 1,119,^{25}.

Should the nature of the accident be recognised, the most appropriate treatment will be to keep the arm at rest in the flexed position, so as to relax the brachialis anticus muscle. In about a month passive motion may be gently commenced.

3. *Fracture of the neck of the radius.*—Surgical authors differ considerably in their estimate of the comparative frequency of this injury, the result chiefly of the difficulty of making an absolutely certain diagnosis during life. South says, that it 'is not an uncommon accident, and very liable to be confused with dislocation of the bone forwards on the outer condyle of the upper arm. It is accompanied with much distortion and swelling, and, being naturally deeply imbedded in the muscles, is difficult to make out satisfactorily. The head of the bone must be grasped with the thumb and finger of one hand, whilst the other draws the lower end of the bone from it, by pulling at the hand alone; and then, upon rotation, if there be fracture, the crepitation will be felt.'‡ The post-mortem proof of such a fracture is, however, almost entirely wanting. As the head of the bone is an epiphysis, and does not unite until the age of puberty, we should expect to find its separation from the shaft more common before that age than at any other period of life.

Malgaigne reports two cases in which a post-mortem examination showed a fracture extending through the head of the radius, both of them in combination with other severe injuries to the neighbourhood of the joint. In the two specimens of fracture of the coronoid process referred to above in the Museum of St. George's Hospital, the head of the radius was also split longitudinally.

B. *Fractures of the middle of the fore-arm.*—1. *Fracture of both radius and ulna.*—The two bones are broken together at this situation more frequently than is either the ulna or radius alone. Direct violence is the most common cause; a blow, the passage of a wheel over the arm, or a fall in which some hard substance is struck. In the numerous cases of fracture of the fore-arm occasioned by falls upon the hand, it is almost always the radius, which receives the shock directly from the carpus, that is broken, the ulna not often participating in the injury. Malgaigne relates a case of fracture of both bones of the fore-arm from muscular action, occurring while digging; the only one on record, as far as I am aware, from this cause.

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* Series i. Nos. 111, 112.

† Op. cit. p. 299.

‡ Translation of *Chelius*, vol. i. p. 559.

The most frequent seat of fracture is about the middle or lower third; the upper part being, from its situation and its more complete muscular covering, less exposed to injury than the more distant. The line of fracture is usually transverse, or nearly so; it is often at the same level in the two bones, or if not, generally higher in the radius than in the ulna. The nature and amount of displacement of the fragments vary much; it may be almost or quite absent; but usually both bones will be bent at an obtuse angle, either forwards, backwards, or on one side; or one only may be bent, its broken ends falling in towards the companion bone. Oblique fractures are generally accompanied by a riding of the fragments, and shortening, more or less marked, of the limb. In transverse fractures, it is not common for the faces of the broken extremities to separate completely, so as to allow them to overlap each other; but this happens sometimes, and the overlapping may be in different directions in the two bones, the lower fragment of the radius being in front of the upper, and that of the ulna behind, or *vice versâ.* Incomplete, or 'greenstick,' fractures of the bones of the fore-arm are very frequently met with in children.

The diagnosis is usually simple; the pain and loss of power, the unnatural bend in the arm, the separate mobility of the upper and lower parts, and the crepitus, are signs which indicate the nature of the accident. These fractures are often troublesome to manage, the fragments having a great tendency to become displaced, and so permanent mal-position of the bones, causing loss of rotation of the fore-arm, is not an infrequent result. The power of rotation is even sometimes lost, in cases where the bones have united in tolerably good position, from deposits of new osseous matter taking place between them, and soldering them together, or, as Lonsdale* suggests, from the upper and lower fragment of the radius being in a different position as regards supination at the period of union; the former being completely supinated by the action of the muscles attached to it, while the latter, in the usual method of treatment, is kept in a semi-prone position; hence, after union, complete supination of the hand becomes impossible. I have found a proof of the truth of this conjecture in an examination of numerous specimens of united fractures of the radius, in the greater number of which the lower fragment was much less supinated than the upper.* Want of union is another and more distressing result, which occasionally follows this fracture. To guard against such untoward events, the splints and bandages have often to be applied tightly, in consequence of which a still greater evil, gangrene of the extremity, has occurred more frequently in this than in any other injury of a similar nature, especially in children.

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* Op. cit. p. 125, and *London Medical Gazette,* vol. ix. 1832.

Treatment.—If there is much displacement and shortening, reduction must be effected by extension applied at the wrist, while counter-extension is made at the elbow, the fore-arm and fingers being semi-flexed to relax the muscles; at the same time the broken ends may be brought into proper apposition by manipulation. The position in which the fore-arm is now to be placed has long been a subject of controversy among surgeons. Although the state midway between pronation and supination, which is most comfortable to the patient, is generally adopted, yet when the fragments are much displaced, and have a tendency to fall together and diminish the interosseous space, complete supination, recommended by Lonsdale, for the reasons above mentioned, and more recently advocated by Malgaigne, is better adapted to produce a satisfactory result.

The objectionable plan of tightly bandaging the limb before putting on the splints, is now justly discarded by most surgeons, on the ground that it prevents the fulfilment of the important indication of keeping the two bones apart. On the contrary, a graduated compress is generally placed lengthwise behind and in front, between the radius and ulna, at the seat of injury, so as to press into the interosseous spaces; over these, straight wooden splints, extending from the elbow to a little beyond the wrist, are fixed, and the fore-arm is suspended in a sling. These compresses have been objected to, as likely to interfere with the circulation of the limb, and, if the splints are properly padded, may generally be dispensed with. It is important that the splints should be fully as wide, or somewhat wider, than the limb, so that the bandages which retain them in place exercise no lateral pressure upon the bones.

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* See especially preps. Nos. 2,950 and 2,951 in Mus. Roy. Coll. Surg.

2. *Fracture of the shaft of the ulna* is almost always caused by direct violence, either in striking against some hard body, as the corner of a door-step in falling, or when the fore-arm is elevated to ward a blow from the head, in which position the ulnar side is turned forwards. The middle and lower portions are most commonly the seat of fracture; the superior strength and thickness of the upper, and its less exposed position, rendering it little liable to injury. Displacement, when it occurs, affects the lower fragment only, the other being retained in its situation by the articulation at the elbow; it may be in any direction, determined by that from which the force acting on it proceeds. If there is no displacement, the appearances of bruising and the swelling and pain will mark the point of injury. Mobility of the lower fragment and crepitus may generally be obtained by holding the upper part firmly, and pressing the lower towards the radius. The subcutaneous position of the greater part of the bone adds greatly to the facility of diagnosis. The radius, acting as a kind of splint, prevents shortening, and assists in keeping the parts in apposition; so that the treatment of this fracture is much less difficult than where both bones are broken. Care should be particularly taken that the broken ends do not incline towards the radius, so as afterwards to impede the rotation of the fore-arm. If there is much tendency to this, pads should be placed between the bones, and the supine position adopted; in other cases, that midway between supination and pronation will be the best. The splints should be straight, one anterior and one posterior; or the starched bandage or gutta-percha may be used. The fore-arm and hand should be supported in a sling.

3. *Fracture of the shaft of the radius.*—Though the radius is broken more frequently than any other bone of the body, this preponderance is chiefly due to the great number of fractures of its lower end, the middle part being probably not more subject to this injury than the same portion of the ulna. It is occasionally, but very rarely, broken immediately below the insertion of the tendon of the biceps into the tuberosity; an accident

which has been, though improperly, described as 'fracture of the *neck* of the radius.'*

Direct violence is the most common cause of fracture of the shaft of the radius, although it may be occasioned by a fall upon the hand. The diagnosis is usually unattended with difficulty, the principal signs being, loss of power of rotation, mobility, and crepitus elicited by pressing the fragments in different directions with the fingers, or on fixing the upper one, and rotating the hand.

The broken ends have a tendency to fall inwards towards the ulna, and so to diminish the interosseous space. This must be guarded against by pads, as directed when speaking of fracture of both bones; the hand should also be supinated; and the general treatment recommended in the next section for fractures of the lower end may be adopted.

C. *Fractures of the bones of the fore-arm in the vicinity of the wrist-joint.*—1. *Fracture of the inferior extremity of the radius.*—Excepting perhaps the middle of the clavicle, there is no single point of the skeleton so frequently the subject of fracture as the lower end of the radius; the reason being, that in falling down the hands are generally thrown forwards, and the whole weight of the body received upon the palmar aspect of the carpus, from which it is directly transmitted to the broad articular surface of the radius; this bone, placed thus between the weight and momentum of the body in falling on the one hand, and the resistance of the ground on the other, gives way at its weakest point, viz. where it commences to expand into the broad articular extremity composed of cancellated tissue, covered with a compact layer much thinner than that of the shaft. The cause, then, of this injury is almost always indirect violence: it may, however, be occasioned by a direct blow, or a wheel passing over the arm; but in such accidents both bones usually suffer. Although met with frequently in both sexes, and at all periods of life, it is a remarkable circumstance, that while up to the age of thirty it is more prevalent among men, yet after middle life the reverse takes place, and as age advances this disproportion between the sexes continues to increase; so that among old women, fracture of the lower end of the radius is more frequent than all other fractures and dislocations of the upper extremity taken together.

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* See two cases by Mr. J. Moore, *London Medical Gazette*, vol. xxxvi. 1845, p. 1079.

The pathology of this fracture has been the subject of many special memoirs, and even of much controversy. The earliest accurate description which appeared of it in our language is by Colles of Dublin;* hence it is frequently designated by surgical writers as 'Colles' fracture.' It has more recently been the subject of an elaborate memoir by R. W. Smith† of the same city; and on the Continent it has attracted the attention of Pouteau,‡ Desault,§ Dupuytren,|| Goyrand,¶ Diday,** Voillemier,†† Malgaigne,‡‡ and others.

The line of the fracture is almost always transverse, occasionally it crosses obliquely from side to side; it is usually situated from half an inch to one inch above the articular surface of the bone. In some instances there is scarcely any displacement, but most commonly the lower fragment assumes a peculiar position with respect to the other, which gives a very marked and characteristic appearance to the limb. In the great majority of cases, this displacement is backwards and somewhat upwards; so that in bones in which unreduced fractures of this kind have consolidated, the posterior surface is found to be considerably shortened, while the anterior retains its normal length. The carpal articular surface also, besides occupying a position more posterior than normal, as regards the shaft, has an inclination backwards, instead of forwards, as in the usual state. So that in fact the inferior fragment has undergone a sort of rotation on its transverse axis, a 'mouvement de bascule,' as the French term it. This change of position is, however, modified by the strong ligaments of the lower radio-ulnar articulation (which do not usually give way) confining the inner side of the fragment more in place than the outer, so that the displacement is more extensive on the side of the styloid process, and the outer border of the bone is shortened to a greater degree than the other; hence it is that the whole

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* *Edin. Med. and Surg. Journal,* April 1814.

† *Treatise on Fractures in the Vicinity of Joints,* 1847, p. 129.

‡ *Œuvres posthumes,* 1783, tome ii. p. 251.

§ *Œuvres chirurgicales,* 1813, tome i. p. 155.

|| *Leçons orales,* 1834, tome iv. p. 161.

¶ *Gazette médicale,* 1832, p. 664, and *Journal hebdomadaire,* fév. 1836.

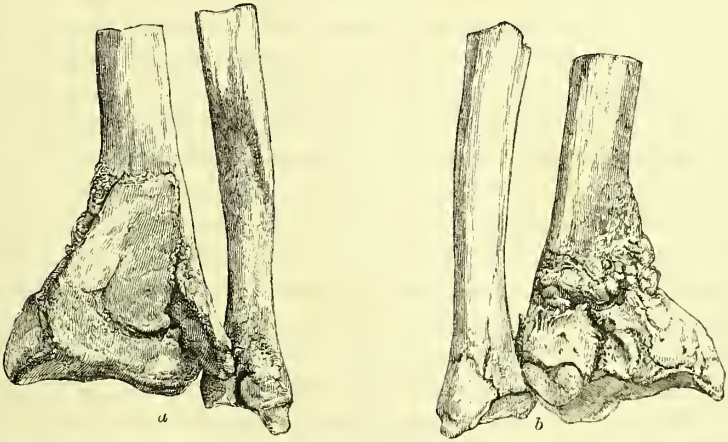
** *Archiv. gén. de Médecine,* 1837, 3^{me} série, tome i. p. 141.

†† Ibid. 1842, tome xiii. p. 261.

‡‡ Op. cit. tome i. p. 603; *Gazette médicale,* 1832, p. 730.

hand, which follows the movements of this fragment, is inclined towards the radial side. It is difficult to conceive that this displacement can be effected in any other way than by a penetration of the posterior surface of the superior fragment into the soft cancellous structure of the inferior; an explanation suggested by Voillemier, and adopted with slight modifications by Malgaigne, Nélaton, and Erichsen, but opposed by R. W. Smith, whose opinion is, that, as a rule, no such penetration takes place, 'the distortion being the result of the combined action of the supinator longus, the extensors of the thumb, and the radial extensors of the carpus.' After a full consideration of the elaborate arguments which have been brought forward on either side to determine this point, it appears to me that the evidence from the examination of specimens of bones in which union has taken place, as well as that derived from the symptoms during life, shows that impaction occurs in a large number of cases, although it cannot be denied that muscular action frequently aids in maintaining the peculiar deformity.* The question can only be finally decided by a greater number

FIG. 101.



Comminuted fracture of the distal end of the radius. *a*, anterior view; *b*, posterior. From a preparation in the Museum of the Royal College of Surgeons.

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* Dr. Smith says: 'In the descriptive Catalogue of the Pathological Museum of St. Bartholomew's Hospital, published in 1846, the same error' (that of attributing the deformity to impaction), 'as it appears to me, has been committed. See No. 78, p. 133, and No. 94, p. 136.' An inspection of the specimens referred to, has left no doubt on my mind that the description in the Catalogue is perfectly correct.

of careful dissections of recent cases, for which opportunities very rarely occur. Sometimes the inferior fragment is split into several pieces, apparently from the force with which the lower end of the shaft has penetrated it.

The symptoms of this injury are so pronounced, that it may almost always be recognised at first sight. The patient is unable to perform the motions of supination and pronation, and complains of much pain, especially about the internal lateral ligament of the wrist, which is put upon the stretch. The hand being articulated to the displaced fragment of the radius, is carried with it backwards and towards the radial side; the styloid process of the ulna is thus rendered extremely prominent. The lower end of the radius forms a marked projection on the dorsum of the wrist, and there is a corresponding depression in front. Often in the first instance this portion is not movable upon the shaft, and there is no crepitus; but after disengaging the impacted ends by powerful extension, both these distinctive signs are usually obtained. If there is much swelling from inflammatory effusion, the distinctive characters will be more or less masked; but now that the nature of the injury is so well understood, it will be next to impossible to mistake it, as was formerly frequently done, for dislocation of the carpus backwards, which, by the way, is an extremely rare accident.

In young subjects, fractures of the lower end of the radius are easily reduced, unite readily, and leave the use of the limb perfectly unimpaired; but in old persons, who, as before stated, are especially liable to this injury, the result is often most unsatisfactory, even after the greatest care has been used during the treatment. It is frequently months before the hand is free from pain, and regains its proper motions, and too often an unsightly, crooked, and permanently stiff wrist remains, to the great inconvenience of the patient, and annoyance of the surgeon.

Treatment.—If the fracture is impacted, extension, while the hand is supinated and adducted as much as possible, is generally required to unlock the ends of the bones. After this is accomplished, there is still a great tendency to displacement from muscular action, which must be overcome as far as possible by mechanical means. Many surgeons use what is called the 'pistol-shaped splint,' well padded and fixed along the back of the fore-arm and hand, so as to keep the latter firmly drawn to the ulnar side, by which means some amount of extension is made upon the lower end of the radius. Another splint, shorter and straight, is adapted to the front of the fore-arm, its lower end resting on a pad which presses on the projecting inferior extremity of the shaft of the radius. According to Dr. F. H. Hamilton, most American surgeons apply the curved splint to the palmar surface, and the shorter straight splint to the dorsal side of the fore-arm. They also flex the fingers over a hand-block, or pad, attached to the former. A single straight splint along the back or front of the fore-arm and hand, is used by some surgeons; while others prefer two straight splints, placed one on each side, with pads so contrived as to press the lower fragment of the radius into place, while the hand is left free, and, being unsustained by the sling which supports the fore-arm, hangs down (to the ulnar side) by its own weight. The advantage gained by this method is, that much of the stiffness of the wrist and fingers, which follows their close confinement in the ordinary method, may be avoided. With very old people, this rigidity often gives so much trouble afterwards, that Velpeau considers it best in such cases to dispense with splints altogether, and merely place the arm upon a pillow.

Many arguments for and against the adducted position of the hand, in the treatment of fractures of the lower end of the radius, have been brought forward. The just view of the subject is probably intermediate between that of its extreme advocates and of those who altogether deny its utility. It is, I think, more advantageous in fractures three or four inches above the articulation than in the cases now under consideration; but in practice I have found little difference in the results of the treatment by the straight or pistol-shaped splint. Much more depends upon the care and accuracy with which the minor details are carried out. The splints should be removed between the third and fourth weeks, and the fingers exercised as much as possible, to overcome their stiffness. There often remains a swelling on the front of the wrist, caused by an indurated condition of the sheaths of the tendons; this must be treated by friction with stimulating liniments, or the application of tincture of iodine.

It occasionally, though very rarely, happens that the lower fragment of the radius is displaced *forwards*. The cause of this injury is said to be a fall upon the back of the hand.*

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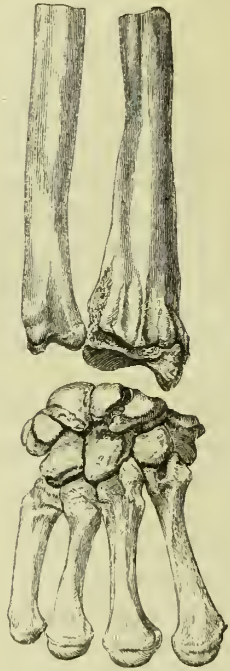
* R. W. Smith, op. cit. p. 162.

In subjects under the age of twenty, separation of the inferior epiphysis of the radius commonly takes the place of fracture of this part. The symptoms and treatment in both cases are very nearly identical.

2. *Both radius and ulna* may be broken close to their lower ends; an injury presenting at first sight much more the appearance of dislocation of the carpus backwards than does fracture of the radius alone, as there is now no lateral displacement of the hand, and consequent prominence of the styloid process of the ulna. Careful attention to the exact seat of the injury will enable the surgeon to form a correct diagnosis. (See p. 833.)

3. Lastly, *the lower end or styloid process of the ulna* alone may be the seat of a fracture, caused usually by violence applied directly.

Fig. 102.



A vertical fracture crosses the junction of the middle and inner third of the scaphoid bone. The lower end of the radius is also fractured; the fracture extends obliquely from a quarter of an inch above the lower border, on the anterior aspect of the bone, to the line of union of the posterior with the articular surface. The drawing represents a preparation in the Middlesex Hospital Museum; Catalogue, No. i. 23, c.; taken from the same patient as Fig. 100 (comminuted fracture of elbow-joint). The same collection contains a second similar preparation.

Fractures of the Bones of the Hand.

1. *Fracture of the carpal bones.*—The form and mode of articulation of the bones of the carpus render them very little liable to fracture, except where there has been great violence, as from machinery, or gun-shot, in which cases the soft parts are also extensively injured. (See page 762.) Simple fractures do, however, occasionally occur, from the passage of heavy weights, as cart-wheels, over the hand, or blows and falls on the wrist. Owing to the fragments being retained in their place by their numerous ligamentous connections with the surrounding bones, there are few symptoms beyond those that might be ascribed to a severe bruise, and it is therefore probable that a fracture of one of these bones may often pass undetected.

As post-mortem evidence of simple fracture of any of the carpal bones is not common, the following case may be worth recording. A man, aged forty, was admitted into the Middlesex Hospital, Jan. 3, 1861, having received in a fall several severe injuries, from the effects of which he died. The right wrist-joint had evidently suffered, though there was no external wound or deformity. Acute inflammation, and ultimately suppuration within the joint, supervened. After death, it was found that a piece about one inch in length was split off from the posterior surface of the lower end of the radius, and a fissure extended almost, but not entirely, across the middle of the scaphoid bone.

The *treatment* consists in keeping the wrist at rest, lightly bound to a splint, and in the use of cold lotions, or other antiphlogistic measures, if the inflammatory symptoms are severe.

2. *Fracture of the metacarpal bones.*—These bones are much more exposed to injury than the last-named. The usual cause of fracture in them is direct violence, but we not unfrequently find it occasioned by striking a blow with, or falling upon, the closed fist. It is met with far more frequently in men than in women, and chiefly between the ages of fifteen and forty-five.

The statements that have hitherto been made as to the comparative liability of the different bones of the series to fracture are very unsatisfactory, owing to the insufficient number of observations upon which they are founded. Of the 113 cases which I have collected from the records of the Middlesex Hospital, in 71 the particular bone is mentioned. Of these, four are double fractures (two of the second and third, and two of the third and fourth), and in one the third, fourth, and fifth bones were broken; making in all 78 fractures. The number belonging to each bone is—

1st	27
2nd	16
3rd	9
4th	12
5th	14
Total . .	78

Probably an undue prominence is here given to the first, as, on account of its distinctive characters, it is more likely than any of the others to be particularised in describing the nature of the accident. Allowing for this probable source of error, we may still place it foremost in liability of fracture, as might be supposed from its position and extent of motion; the others seem to follow in order, as their situation exposes them to injury, the third or middle bone being last.

The fracture is usually in the middle or distal third of the bone; it is transverse or oblique, often attended with very little displacement, in which case the mobility of the fragments and the crepitus are the chief signs of the injury. Often, however, there is a displacement of the distal fragment, the head sinking down towards the palm, and the upper end forming with the extremity of the proximal fragment an angular projection on the dorsum of the hand. Sir A. Cooper* describes the fracture of the *head*, or more properly of the *neck*, of these bones; in young subjects this is probably a separation of the epiphysis.

The *treatment* of this injury recommended by the eminent surgeon just named, consists in causing the hand to grasp a large ball, and then binding a roller round the whole. I have generally modified this method by using a common rib-roller instead of the ball, and fixing the hand over it by means of adhesive plaster. Where there is much displacement, in order to obtain greater accuracy of adjustment, the plan recommended by Malgaigne is to be preferred. A thick compress is to be placed under the head of the bone so as to raise it, and another over the projection on the dorsal surface; these are kept in place by two broad splints placed across the hand, one above and one below, their ends being firmly drawn together by strips of plaster. The fingers should be left free, so as to avoid too great an amount of stiffness. If the metacarpal bone of the thumb is broken, it must be treated in the same manner as one of the phalanges, which it resembles so closely in its characters.

3. *Fractures of the phalanges.*—From their very exposed situation, these small bones are often broken, usually with wound or severe bruising, amounting frequently to complete comminution of the whole member. Simple fracture of the phalanges is, however, by no means uncommon, and is generally caused by direct and occasionally by indirect force. The first phalanx, being largest and most fixed in position, seems to suffer most; but we have not yet sufficiently reliable data to determine even approximatively the relative frequency of injury to the different bones of this series. The fracture usually occurs about the middle of the bone; and although there is rarely much displacement, the diagnosis is generally established without difficulty from the crepitus and mobility of the fragments.

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* Op. cit. p. 506.

The *treatment* usually recommended is, to fasten a narrow straight wooden splint beneath the finger with a small pad opposite the middle of the broken phalanx, to fill up the concavity which naturally exists between the joints. The splint may be more conveniently fixed to the dorsal surface, especially when it is one of the phalanges of the thumb that is broken. A more comfortable support is given by a splint of gutta-percha or pasteboard, moulded to the shape of the finger, which may then be allowed to be slightly flexed at each of the joints. It may be released from its confinement, and passive motion may be commenced, at about the end of the third week.

DISLOCATIONS OF THE BONES OF THE UPPER EXTREMITY.

Dislocations of the Clavicle.

The articulation between the sternum and clavicle may properly be regarded as the first point at which a luxation of any of the bones of the upper extremity can take place. As fracture of the clavicle is such a common accident, it has been remarked with surprise by authors, that, considering the extreme smallness and shallowness of the sternal articular surface, dislocation does not oftener occur at this point; and explanations are sought for in the strength of the ligaments, &c. The circumstance is more readily accounted for by the fact, that the clavicle is so confined by surrounding structures as very much to limit the amount of movement at the joint, and it is consequently impossible either that the articulating surfaces can undergo much change in their relation to each other, or that any of the ligaments can be put greatly on the stretch. *Cœteris paribus*, the greater the extent of motion in a bone, the greater the liability to dislocation. Again, the causes which produce dislocation of the clavicle are different from, and not so frequently in operation as, those which usually occasion a fracture. Its relative frequency, according to the table at p. 764, is 3·10 per cent.

The cartilage of the first rib prevents displacement of the head of the clavicle downwards, but it may occur in any other direction. Following the order of frequency in which they are met with, we may describe:

1. Dislocation forwards. 2. Dislocation backwards. 3. Dislocation upwards.

1. *Forwards.*—This may be complete or incomplete: in the former case, the head of the bone, besides projecting forwards,

is depressed below its natural level; in the latter, it is usually slightly raised. The ordinary cause of this dislocation is some violence which pushes the outer end of the clavicle backwards, as a fall or blow on the front of the shoulder. In children, it has been produced by simply pulling the arm.* It has been observed at most ages, from birth † to eighty-six,‡ more frequently in males than females. The prominent head of the clavicle seen and felt in its abnormal situation, covered only by the integument, leaves no doubt as to the nature of the injury, except in partial dislocations, where there is much swelling, or in very fat subjects.

Treatment.—The bone is usually reduced without difficulty by drawing the shoulder outwards and backwards, the surgeon's knee being placed between the scapulæ of the patient; while at the same time, if necessary, an assistant presses the head of the bone back into its place. The great disposition that it has to slip out again has led to the invention of many methods intended to retain it in place; but even after the greatest care, more or less deformity often remains. Fortunately the utility of the limb is not materially impaired, even if the bone remains unreduced. The two objects to be aimed at are: (1) to keep the shoulder fixed, and thrown upwards, outwards, and backwards; and (2) to exert pressure upon the head of the clavicle.

A pad in the axilla, a figure-of-eight bandage to the shoulders, with a sling to support the elbow, or, in fact, any of the apparatus used in fractured clavicle, will fulfil the former indication; while for the latter a common hernia-truss may be applied, the pad being placed on the projecting bone, and the spring passing under the axilla of the sound side, as recommended by Nélaton. The pressure requires to be kept up from six weeks to two months, though at the end of the former period passive motion of the arm and shoulder should be commenced, in order to overcome the stiffness of the joints that so long a confinement must necessarily occasion. Velpeau, upon the supposition that the displacement is chiefly due to the action of muscles, proposes to relax these by carrying the elbow inwards and forwards to the lower part of the sternum, so that the hand may rest upon the opposite shoulder; the outer end of the clavicle will then be inclined upwards and forwards, and pressed inwards.*

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* Melier, *Archiv. gén. de Médecine*, tome xix. p. 53.

† Fergusson, *Practical Surgery*, 4th edit. 1857, p. 249.

‡ Brasdor, *Mém. de l'Acad. de Chirurg.* tome v. p. 588.

2. *Backwards.*—This form of dislocation has been produced by a violent fall, driving the shoulder inwards and forwards,† by the shoulders being pressed together between a carriage-wheel and a wall, or by a force applied directly, so as to push the inner end of the clavicle backwards, as a kick from a horse. The head of the bone usually lies behind the upper part of the sternum, rather below its normal level. In extreme cases, symptoms dependent upon pressure upon the trachea and œsophagus are produced, as in that related by Sir A. Cooper, in which Mr. Davie of Bungay had to saw off the sternal end of the bone to prevent death from this cause: this, however, was not an example of traumatic dislocation, but was produced gradually by a progressively increasing curvature of the spine.

A characteristic case occurred in the practice of my colleague, Mr. De Morgan, at the Middlesex Hospital, in 1852, which I shall relate briefly, as illustrating the usual symptoms and treatment of this accident.‡ A girl, ten years of age, was knocked down by a carriage, and appears to have been trodden on by one of the horses. On admission, she suffered much from dyspnœa, the head was inclined forwards, and could not be raised without extreme pain. There were marks of bruising over the right shoulder and clavicle. Where the head of the bone should be, there was a depression into which the finger might be thrust, and the articular surface of the sternum could be distinctly felt, while the head of the clavicle was evidently behind it. The distance from the middle line to the acromion was shortened by a quarter of an inch. 'On placing the knee against her spine, and gently drawing the two shoulders backwards, the bone was easily restored to its proper place, causing obvious relief to the dyspnœa; but immediately on leaving hold of the shoulders, the bone fell back, and the dyspnœa returned. A splint was then placed across the shoulders, with a pad between it and the spine, the shoulders being drawn to the splint by a bandage; by these means the bone was kept firmly in its place, pillows being so arranged along the patient's back that the splint should not feel uncomfortable. On the apparatus being fixed, she could lean her head backwards, and stated that her pain was much relieved.' The splint was kept on for a fortnight; the bone being then quite steady in its place, she was allowed to remain in bed without any bandage. The articulation became in four weeks quite as firm as that on the other side, and the arm could be moved without causing any pain.

South relates a case of compound dislocation of the sternal end of the clavicle backwards, caused by a blow with the sharp end of a pickaxe.§

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* *Journal hebdom. de Méd.* May 30, 1835.

† See a case, caused by a fall while wrestling, by Mr. W. Brown of Callington, *Medical Gazette*, Aug. 1, 1845.

‡ Reported by Mr. S. W. Sibley, *Medical Times and Gazette*, 1852, vol. i. p. 415.

§ South's *Chelius*, vol. i. p. 778. See also, on this subject, Baraduc, *Mémoires sur les Luxations de la Clavicule*, Paris, 1842.

3. *Upwards.*—This accident has only recently acquired an established place in surgical pathology. Malgaigne has collected five examples, and Dr. F. H. Hamilton has added another, which happened in America. They seem all to have been occasioned by a violent force which carried the shoulder downwards and inwards. The symptoms are very marked, the head of the bone being felt above the upper border of the sternum, lying between the sterno-mastoid and the sterno-hyoid muscles. There is probably complete rupture of all the ligaments of the joint, as well as the costo-clavicular ligament.

Reduction is easily effected by drawing the shoulder outwards and upwards, while the dislocated head is pressed down; but to retain it in this position is difficult, if not impossible. Malgaigne found the functions of the clavicle perfectly restored six months after the accident, although the sternal end was nearly a quarter of an inch above, and as much to the inner side, of its normal situation. In the case mentioned by Dr. Hamilton, the displacement was still greater; but the patient stated 'that he felt no inconvenience or abatement of strength in the arm, except when he attempted to lift weights above his head.'*

Dislocations of the Scapula.

These injuries are usually described as '*dislocations of the acromial end of the clavicle*,' but it seems preferable, for the sake of uniformity in our nomenclature, which has now discarded such terms as 'dislocation of the radius and ulna upon the carpus,' 'dislocation of the tibia at the ankle,' &c., to consider it as a dislocation of the acromion process of the scapula from the clavicle, the latter being the more fixed point and nearest to the trunk. This designation has already been adopted by Skey † and Maclise.‡ Luxation at this joint is more frequent than at the sterno-clavicular articulation.

In the great majority of cases, the acromion is forced *beneath* the outer end of the clavicle; occasionally the reverse happens, viz. the acromion is situated *above* the clavicle; and a third form has lately been described, in which the displacement is carried so far that the coracoid process, as well as the acromion, are placed above the clavicle.

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* Op. cit. p. 523.

† *Operative Surgery*, 2nd edit. 1858, p. 94.

‡ *On Dislocations and Fractures*, 1859.

The cause of this injury is nearly always direct violence applied to the scapula, as in a fall in which the back or outer part of the shoulder comes in contact with the ground or some hard body, or a blow or kick upon the same part. The symptoms of the first and most usual variety are tolerably well marked. There is pain in the articulation; the motions of the arm, especially upwards, are restrained; the shoulder is depressed, and approximated to the sternum; the arm apparently lengthened, and the projection formed by the outer end of the clavicle lying upon the acromion process, is very easily recognised beneath the skin. In partial dislocations the symptoms are similar, but much less marked.

Treatment.—If the shoulder is drawn backwards, and the outer end of the clavicle pressed upon, the bones are usually restored to their natural relation. There is always great difficulty in retaining them in position, owing to the flatness and obliquity of the articulating surfaces, as well as the contraction of the clavicular portion of the trapezius muscle; but fortunately, although exact coaptation may not be obtained, the ends of the bones appear to adapt themselves to their new conditions, and the utility of the limb is but little impaired. The shoulder must be fixed, and, in order to keep the scapula raised, and the outer end of the clavicle depressed, a stout compress should be placed upon the latter point, and retained by a broad band passed over it, and under the elbow of the same side, and tightened and fixed by a buckle. If greater pressure is required, a Petit's tourniquet, as used by M. Laugier, may be applied in the same manner. For the exact details of this arrangement, the reader is referred to special treatises on the subject;* but much must be left to the ingenuity of the surgeon in each individual case.

The second and third forms of this dislocation mentioned above are extremely rare. Only three unequivocal examples are recorded of the former, and there are some doubts as to the authenticity of the published cases of the latter.

Two instances have been reported of dislocation both at the sterno-clavicular and acromio-clavicular articulation in the same subject, or '*simultaneous dislocation of both ends of the*

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* Especially Malgaigne, op. cit. tome ii. p. 440.

clavicle;' the first by Richerand, and the second by Morel-Lavellée.*

Dislocations of the Humerus.

The humerus is dislocated nearly as frequently as are all the other bones of the body together. The statistics of Malgaigne, and several other authors, assign a still larger proportion; but this arises from the fact that many of the luxations of smaller bones, as phalanges, are evidently omitted from their tables. Its relative frequency in the table at p. 764 is 53 per cent.

The peculiar structure of the shoulder-joint, the shallowness of the articular surface of the scapula, the large size and globular form of the head of the humerus, the very extensive movements and long leverage afforded by the arm, and its frequent exposure to injury in protecting the more important central organs of the body, are all circumstances which contribute to the facility and frequency of dislocation. On the other hand, the free mobility of the scapula has, to a certain extent, a counterbalancing influence.

Dislocation of the humerus is an accident chiefly met with in middle and advanced life; it is extremely rare during childhood and youth. A case was brought to the Middlesex Hospital (August 5, 1860) of a dislocation forwards, in an infant fourteen days old. The arm had been violently pulled and twisted. Mr. F. H. Watts, the house-surgeon, made such a careful examination as to leave no doubt respecting the nature of the injury, and on extension being applied, it was reduced with a characteristic snap.

Common as these injuries are, their pathology is still imperfectly understood, and great discrepancies exist in the classification and descriptions given by various writers who have directed their attention to them. The modern French surgeons particularly have arrived at very different conclusions to those generally adopted in this country, not only as to the usual situation of the head of the humerus, but in regard to several other important points, even in the most common forms of dislocation.

As want of precision in the terms used in describing the different varieties of luxation has hitherto been a principal source of obscurity, it will be necessary, before proceeding further, to adopt a definite and intelligible system of nomenclature. The obliquity of the glenoid fossa, and the variations in the position of the scapula, render such words as downwards, forwards, inwards, &c., very inefficient as distinctive designations of particular forms of dislocation. Names derived from the relation of the head of the bone in its new situation to important contiguous osseous structures are more concise, expressive, and definite. Adopting this method, all the possible dislocations of the humerus readily group themselves into the following five divisions:—

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* *Gazette des Hôpitaux*, 1859, No. 33.

1. Subcoracoid.—Forwards and slightly downwards. On to the neck of the scapula, in front of the glenoid fossa, and immediately below the coracoid process. *Common.*

2. Subglenoid.—Downwards and forwards. Head of the humerus in front of the inferior costa of the scapula, below the glenoid fossa. *Rare.*

3. Subclavicular.—To the inner side of the coracoid process; under the clavicle. *Very rare.*

4. Supracoracoid.—Upwards and forwards. On to the fractured coracoid process. *Only three cases reported.*

5. Subspinous.—Backwards. On to the back of the neck of the scapula, beneath the spine or posterior edge of the acromion. *Very rare.*

These names are all recognised in the system of Malgaigne; some of them may be not altogether free from objection, but it seems better to retain them than to run the risk of adding to the confusion by introducing new ones. For the sake of greater simplicity, the number of this author's divisions is reduced; his incomplete and complete subcoracoid and intracoracoid being included under one head, for reasons which I shall give presently, and his two forms of dislocation backwards being also classed together. Undoubtedly varieties are frequently met with intermediate between several of these forms, especially the first and second, but it appears unnecessary to give them separate names.

I shall commence with the description of the most common form.

1. *Subcoracoid.*—Under this term are included dislocations which Malgaigne considers as belonging to two distinct varieties, and which he respectively designates *subcoracoid* and *intracoracoid.* Although there are doubtless characters by which well-marked cases of either can be determined, the difference between

them is slight, and being rather of degree than of form, I can see no practical advantage in retaining it in our classification. Perhaps, for the purposes of critical investigation, they might be regarded as sub-varieties of one common form. The main distinction between them seems to be this—in both cases the groove between the articular head of the humerus and the great tuberosity, rests on the same part of the anterior edge of the glenoid fossa. If the posterior scapular muscles are entire, being put on the stretch, they cause the head of the humerus to be rotated outwards, and the *subcoracoid* variety is produced; if the injury has been inflicted with greater violence, and these muscles are separated from their attachments, or the greater tuberosity broken off, or if, perhaps from some other cause, their action is diminished, the humerus is allowed to turn more inwards, and the greater part of its head is placed internal to a line falling from the tip of the coracoid process, and the injury is called *intracoracoid*. The name '*subcoracoid*' seems preferable for all these cases, as it is extremely expressive of the position of the head of the bone; while '*intracoracoid*' would have been more correctly applied to that form of dislocation in which it is truly on the inner side of the coracoid process, the one commonly called '*subclavicular*.'

Although quite unrecognised in the earlier, and only doubtfully admitted into many recent systematic works in this country, numerous cases of subcoracoid dislocation, in which the anatomical characters are accurately described, are to be found in the pages of our surgical treatises and periodicals. One of the earliest of these is the well known case (now preserved in University College Museum) recorded by Thompson nearly a century ago.* A reference to the figures in the quarto edition of Sir A. Cooper's work will show that at least one of the specimens from which he described the anatomical characters of dislocation *downwards* really belonged to this form; and that the description of the position of the head of the bone in the text must have been influenced by the previous opinions of the writer.† The same may also be said of the case cited by this distinguished surgeon, as an evidence of 'partial dislocation.' Many of the cases that have been published of dislocation forwards and inwards, or subclavicular, are nothing more than specimens of this variety. Of forty-one specimens of dislocation at the shoulder-joint preserved in the different anatomical museums in London, as many as thirty-one undoubtedly belong to this form;* and of fifty recent cases which have come under the observation of myself, or gentlemen in whom I can place perfect confidence, and of which I have full particulars, in forty-four the head of the humerus was placed so closely beneath the coracoid process as to justify the appellation of 'subcoracoid.' In the face of these facts, it is difficult to understand how the widespread error of regarding the subglenoid as the typical form of dislocation at the shoulder-joint, should have been so long maintained. A simple process of reasoning upon the anatomical structure of the part would suffice to show that, whenever the humerus is thrown from its socket, it will almost of necessity be drawn upwards until it is arrested either by the coracoid process in front, or the spine or acromion behind. Even in the dead subject, when dislocation is artificially produced by forcibly elevating the arm, while the scapula is fixed, the humerus is almost always drawn up close against the under surface of the coracoid process; *à fortiori*, in the living, must the action of the deltoid, coraco-brachialis, and biceps cause it to assume this position. In fractures about the neck of the humerus, the action of these muscles in raising the lower fragment has long been recognised. The truth is, that nearly all the cases of dislocation 'into the axilla,' or 'downwards,' described as so common by Sir A. Cooper, and all subsequent British authors, have really been examples of this variety, to which the anatomical characters of the more rare 'subglenoid' dislocation have been erroneously applied.

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* *Med. Obs. and Inquiries,* 1762, vol. ii. p. 340.

† Fifth edit. 1826.

Subcoracoid dislocation may be produced either by a direct force applied to the upper part of the humerus, driving it forwards and inwards, as a blow or fall upon the shoulder; or, secondly, by forcible elevation of the distal end of the humerus, such as may be caused by a fall upon the elbow or hand, when extended from the body. In the forty-four cases above mentioned, the causes were as follows:—falls or blows upon the shoulder, in eighteen; upon the elbow, in five; upon the hand, in ten; while in eleven cases the cause was of doubtful or exceptional nature, including two from muscular action. Of these, one took place in attempting to strike a violent blow at a man, who eluded the stroke; the other in putting on a coat. In the last case, however, the humerus had been frequently dislocated before.

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* See a paper by Mr. Flower, *Trans. Path. Soc.* vol. xii.

Symptoms.—The patient complains of pain about the joint, especially on the inner part, along the course of the great nerves of the brachial plexus, sometimes extending down the arm as far as the fingers, and accompanied by a sensation of numbness. He is quite unable to move the arm at the shoulder; the elbow projects from the side, and cannot be made to touch the chest, at least without causing pain; it is sometimes carried rather behind, sometimes in front of the body, and is frequently rotated rather inwards, but occasionally outwards. The movements of the fore-arm and hand are not impaired. On examining the shoulder more closely, and comparing it with the uninjured side, a striking change is apparent in its form—especially distinct, of course, if the patient is thin and no great inflammatory swelling has taken place. The natural roundness is lost, the acromion appears remarkably prominent, and beneath it there is a depression into which the fingers can be pressed; and in some subjects even the form of the glenoid fossa of the scapula can be distinguished through the fibres of the deltoid. The axis of the humerus is evidently altered; instead of being directed to the glenoid fossa, it points to a spot internal, anterior to, and below it. The limb usually appears lengthened; but on carefully measuring from the acromion process to the external condyle, and comparing it with the opposite side, we find it frequently equal, or somewhat shorter. Of fourty-four cases of subcoracoid dislocation, the arm was elongated in nineteen, unaltered in eight, and shortened in seventeen; the greatest elongation being one inch, the greatest amount of shortening $\frac{7}{8}$ inch. Measurement of the vertical circumference of the shoulder, by carrying a tape over the acromion and under the axilla, always gives an increase of from one to two inches over the uninjured side; an important diagnostic sign, common to all forms of dislocations of the humerus, as pointed out by Mr. Callaway.* The anterior form of the axilla is deeper and fuller than natural, the pectoral muscle being raised by a rounded swelling, which partly effaces the subclavicular fossa. On placing the fingers in the axilla, the upper and anterior part of this space is found to be occupied by the head of the humerus, here covered only by the integument, and moving readily with every movement communicated to the elbow. Or it may be that the upper part of the shaft only is felt at first in the axilla; but on raising the arm from the body, the globular form of the head can generally be detected.

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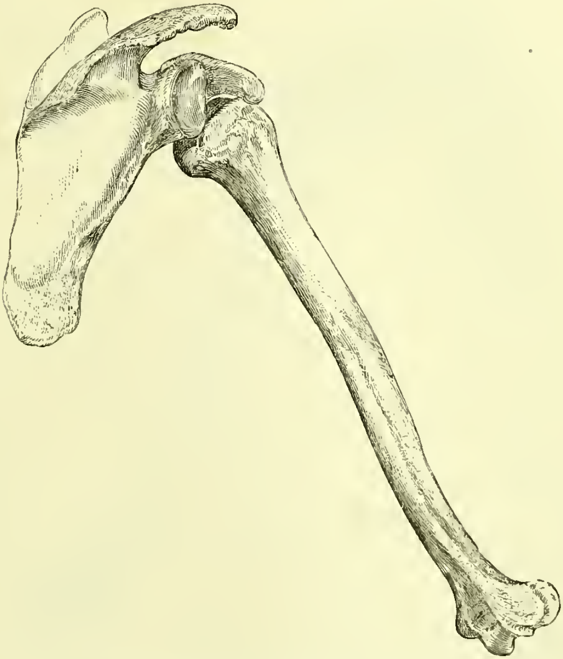
* *Dissertation upon Dislocations and Fractures of the Clavicle and Shoulder-Joint*, 1849.

Abundant opportunity is afforded in our museums of studying the effects of this accident, both in the recent state and when left long unreduced; and its usual anatomical characters can be ascertained with great precision when it is artificially produced in the dead subject.

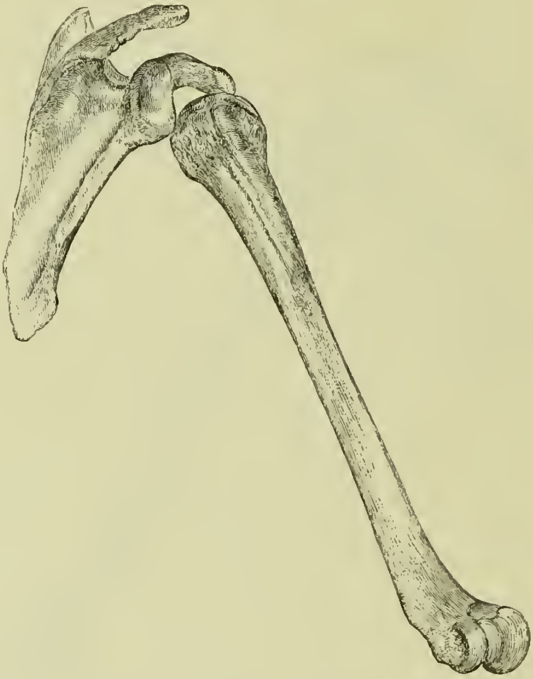
FIG. 103.



Intracoracoid (Malgaigne) dislocation of humerus. From a model by Mr. Flower, in the Middlesex Hospital Museum.

The head of the humerus lies on the anterior surface of the neck of the scapula, immediately below the coracoid process, in front of, internal to, and rather lower than, its normal situation. That part of the anatomical neck which separates the articular surface from the great tuberosity rests upon the anterior edge of the glenoid fossa. The subscapular muscle is raised from the neck of the scapula, and stretched over the front of, or above the head of, the humerus. The muscles from the back of the scapula (supraspinatus, infraspinatus, and teres minor) are drawn tightly across the glenoid fossa, or one or more of them may be ruptured, or detached from the bone. A portion, or the whole, of the greater tuberosity is frequently separated, when it may be drawn into the glenoid fossa by the action of the muscles inserted into it, or may be retained in connection with the humerus by the periosteum, or the capsular ligament. The long tendon of the biceps is rarely, if ever, injured.* The muscles that descend from the coracoid process to the humerus are stretched by the projection of the head of the bone forwards, and the great vessels and nerves are displaced inwards. Occasionally the circumflex nerve is pressed upon to such

Fig. 104.



Subcoracoid dislocation of humerus. From a model by Mr. Flower, in the Middlesex Hospital Museum.

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* As Dr. Hamilton has recently asserted that, 'contrary to what has been affirmed by Sir Astley Cooper, the tendon of the long head of the biceps is often broken asunder, or detached completely from its insertion' (op. cit. p. 535), I may mention that the statement in the text is founded on examination of numerous specimens and reports of dissections.

an extent as to cause paralysis of the deltoid muscle.* Lastly, the capsular ligament is lacerated more or less extensively, anteriorly and inferiorly, the upper end of the humerus having escaped through the aperture.

When left long unreduced, important changes take place in the affected structures. Those that are common to all dislocations, as the formation of a new capsule and fibrous socket, need not be detailed here, but the peculiar alterations in the contiguous extremities of the two bones belong to the special part of the subject.

In process of time a new shallow socket is formed upon the anterior surface of the neck of the scapula, partly by absorption of old bone, and partly by deposit of new, around its edge. The exact position of this socket varies according to the degree of displacement of the humerus: in the first variety (*subcoracoid* of Malgaigne), the new cavity is formed more or less at the expense of the anterior portion of the glenoid fossa, which is gradually worn away, so that in some cases the original socket is finally almost entirely lost. A corresponding change takes place in the head of the humerus: where it rests upon the edge of the glenoid fossa, absorption occurs, so that a groove is excavated, usually between the articular head and the great tuberosity. With continued friction, this increases in size simultaneously with the changes in the scapula; the two accommodate themselves to each other, and ultimately the head of the latter bone presents a double articular surface, separated by a vertical ridge; the posterior portion being part of the old glenoid cavity, the anterior the newly-formed socket. These respectively articulate with the two sides of a wide groove placed vertically on the head of the humerus, and thus a rude kind of joint, which allows of a certain amount of motion, is formed. In consequence of the absorption that has taken place in both bones, the head of the humerus has by this time made considerable progress towards regaining the position it occupied before the injury, and therefore the external signs of dislocation become to a certain extent removed. The under surface of the coracoid process, especially near its tip, is almost always found smooth and eburnated, having entered into the formation of the new articulation.† If the head of the humerus is placed further under the coracoid process (*intracoracoid* of Malgaigne), the new socket upon the neck of the scapula is formed quite outside the margin of the glenoid fossa, upon which it does not encroach. It is then a simple cup-shaped depression, and the head of the humerus undergoes none of the changes above described, but is generally worn away on the side of the greater tuberosity by the friction against the anterior edge of the glenoid fossa, and hence assumes a somewhat oval shape. In these cases the coracoid process is not usually a part of the new articulation. Between the two extremes, all intermediate varieties are found; the position of the new socket, quite free from, or more or less encroaching upon, the glenoid fossa, the head of the humerus unaltered, flattened on its outer side, or grooved, being circumstances which all depend upon the exact situation in which the bone has found its new lodgment. As in unreduced dislocations of long standing elsewhere, the surfaces of the bones which are in contact are generally divested of cartilage, and in places hard and polished.

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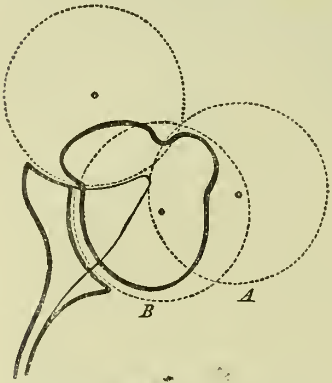
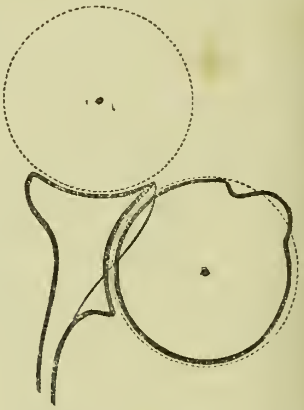
* See a preparation in the Museum of St. Bartholomew's Hospital, A 42.

† Specimens which have presented these characters have generally been cited as examples of 'partial dislocation.'

Fig. 105.



Subcoracoid dislocation; first variety. The circle *A* shows the position of the head of the humerus in recent dislocations; *B* the same when left long unreduced, the new socket encroaching upon the glenoid fossa, the head of the humerus grooved by the pressure of the ridge between the old and new socket. Specimens in this condition have generally, but incorrectly, been described as 'partial dislocation.' From Mr. Flower's paper on the 'Changes in the Shoulder-joint,' &c., *Path. Trans.* vol. xii. p. 183.



Subcoracoid dislocation; second variety (*intracoracoid* of Malgaine). New socket on front of neck of scapula, not encroaching on glenoid fossa; no grooving of the head of the humerus, but the greater tuberosity partially worn away. Ibid.

As the history of the case is unknown in most of the museum specimens, it is difficult to determine the length of time required to effect these changes; probably it varies much under different circumstances. In a specimen in St. Bartholomew's Hospital Museum,[*] in which the accident is said to have occurred three months before death, absorption of the anterior edge of the glenoid fossa has already commenced, and some bone is deposited in the margin of the new socket.

2. *Subglenoid.*—As every intermediate condition may be met with between this and the last, it may be regarded as a variety of that common injury, in which the head of the humerus, instead of being drawn up against the coracoid process by the action of the muscles passing from the shoulder to the arm, has remained at some distance below this point.

According to Malle, the principal circumstance which prevents the bone ascending, seems to be that the anterior portion of the capsular ligament remains entire, rupture of the lower part only having taken place.[†]

In the most characteristic cases, the head of the humerus is thrown below the glenoid fossa, and rather forwards and inwards, resting upon the inner border of the inferior costa of the scapula, and may be felt very prominently in the axilla. The symptoms are much the same as in subcoracoid dislocation, but rather more marked. The depression beneath the acromion is greater; the arm is separated farther from the side, and is generally lengthened, but occasionally is unaltered in this respect, or it may be even shortened. This variation in length may be accounted for, partly by the uncertain position of the head of the humerus, which may be either close upon the edge of the glenoid cavity, or farther back in the subscapular fossa, and partly by the diminution of the distance between the acromion and the external condyle, dependent upon the projection of the elbow from the side.[‡] On the whole, the length of the arm is little to be depended on as a diagnostic mark of dislocation. The main distinction between this and the last, is the interval, of from one to two fingers' breadth, felt between the coracoid process and the head of the humerus.

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[*] C 103.

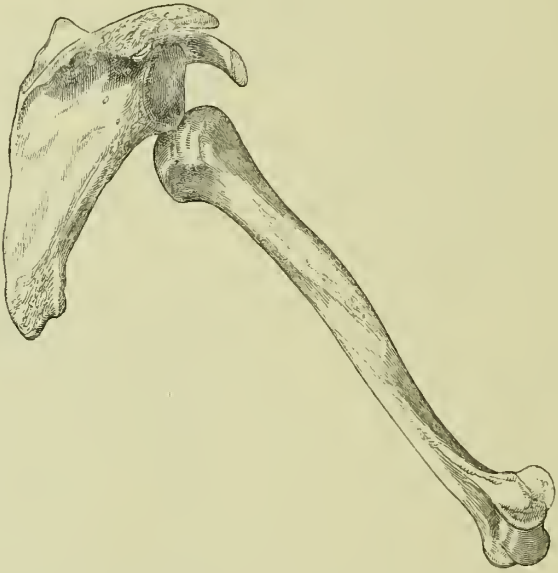
[†] 'Mémoire sur les Luxations scapulo-humérales,' *Mém. de l'Acad. de Méd.* tome viii. p. 595. See also Goyrand, 'Nouvelles Études sur la Luxation en bas ou sous-glénoïdienne,' *Mém. de la Soc. de Chirurgie,* tome i. p. 21.

[‡] Well illustrated by a diagram in Callaway's *Essay on the Shoulder-Joint,* p. 109.

The most common cause of subglenoid dislocation is a fall upon the hand or elbow; it rarely proceeds from a direct blow upon the shoulder.

In the only two specimens of unreduced dislocations of this kind that I have been able to find in the anatomical museums of London, a new osseous socket has formed for the head of the humerus on the upper part of the anterior border of the inferior costa of the scapula, encroaching considerably upon the lower and anterior part of the glenoid fossa. One of these* has been figured by Sir A. Cooper, and its subsequent reproduction by other authors has contributed much to confirm the error of regarding this as the usual form of dislocation of the shoulder. From examination of specimens in museums, and from numerous recent cases, I should conclude that not more than one in ten

Fig. 106.



Subglenoid dislocation of humerus. (From a model by Mr. Flower, in the Middlesex Hospital Museum.)

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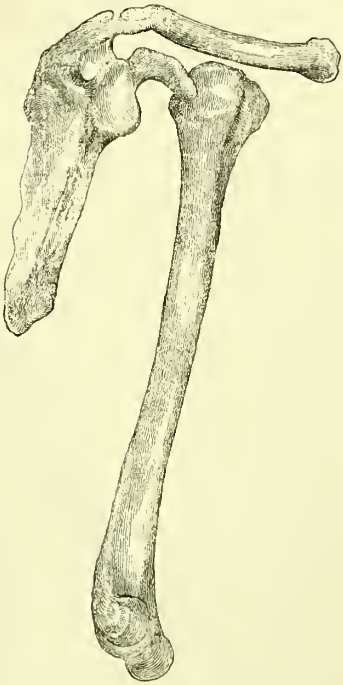
* Now in the Museum of St. Thomas's Hospital, B 11. The other is in the Museum of the Royal College of Surgeons, No. 3,275. There is a specimen in King's College Museum (No. 1,342) which is intermediate between subcoracoid and subglenoid.

of all dislocations of the humerus can properly be called subglenoid.

3. *Subclavicular.*—'The head of the os humeri placed below the middle of the clavicle, and on the sternal side of the coracoid process.' As the last may be regarded as a variety of the ordinary form of dislocation in which the head of the humerus is placed unusually low, so may this be considered as one in which it has passed farther than common in an inward and upward direction. The cases in which the position of the bone exactly corresponds to the above definition of Sir A. Cooper must be very rare indeed, although there are a sufficient number on record to prove the possibility of its occurrence. In one example described by Malgaigne, the head of the humerus was thrust between the deltoid and the pectoralis major, and was only covered in the interval by the integuments..

We know little of the anatomical characters of this injury, and there is no preparation in any of the London museums which exhibits them. In one specimen in St. Bartholomew's Hospital Museum,* the head of the humerus is said to have been 'found resting on the subscapular fossa, and immediately below the clavicle;' but it has unfortunately been removed from this situation in putting up the preparation. In two cases of unreduced dislocation in another museum, in which the head of the bone is described in the catalogue as being 'under the clavicle,' the new socket is distinctly seen to be immediately below the coracoid process. This, I suspect, has been really the case in most of the so-called 'subclavicular' dislocations

Fig. 107.



Subclavicular dislocation. (From a model by Mr. Flower, in the Middlesex Hospital Museum.)

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* Series iii. No. 55.

which have been put on record. In consequence of the subcoracoid not having been recognised as a common variety, any dislocation that was not subglenoid, was necessarily supposed to be subclavicular.

The characteristic symptoms, according to Malgaigne, are as follows: the arm is pressed against the chest, it appears in some cases to be lengthened, in others shortened; the elbow is but slightly removed from the side, and points either directly outwards or somewhat backwards. The head of the humerus is felt on the inner side of the coracoid process, making usually a very apparent projection forwards. Sometimes it is by no means so conspicuous, but lies deeply in the subclavicular fossa. It approaches the clavicle in some cases so nearly as to touch it. In the axilla the shaft is felt, but not the head of the bone, even when the arm is raised to a right angle with the body. The causes are either a violent blow or fall directly on the outside of the shoulder, or a fall upon the hand or elbow, pushing the humerus directly upwards and inwards.

4. *Supracoracoid.*—Malgaigne founded this variety upon a single case, in which the head of the humerus appeared to be dislocated upwards and forwards, and rested upon the coraco-acromial ligament, touching externally the inner border of the acromion, internally the coracoid process, which it covered, and projecting under and raising the deltoid.[*]

More recently, Mr. Holmes has published an account of the dissection of a case where the coracoid process being fractured, the head of the humerus rested on its stump, and on the clavicle, fairly out of, above, and a little anterior to, the glenoid fossa, and, having passed through the fibres of the deltoid muscle, was only covered by the integument. The long tendon of the biceps was displaced to the outer side of the head of the bone. The preparation is now in the Museum of St. George's Hospital. In the same paper the symptoms of an apparently similar case, observed by Mr. Prescott Hewett, are described.[†]

5. *Subspinous.*—This is also a rare form of injury, but one of which the characters are so well marked, that it is not liable to be confounded with any of the others. There are four good specimens, illustrating its effects when left unreduced, in the anatomical museums of London. Out of 159 cases of scapulo-humeral luxation recorded at the Middlesex Hospital, three are assigned to this variety.

Malgaigne describes two forms of dislocation backwards, 'subacromial' and 'subspinous.' As the former is only a less complete variety of the latter, it seems unnecessary to retain the distinction. The subacromial is undoubtedly the most common; but the name is objectionable, as it does not express any change from the normal situation of the head of the humerus.

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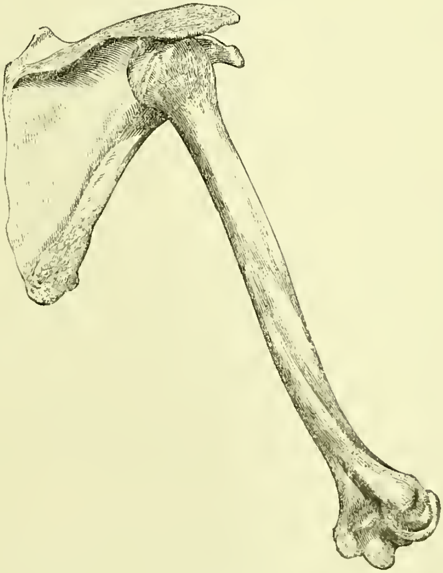
[*] Op. cit. tome ii. p. 530.

[†] *Medico-Chirurg. Trans.* vol. xli. p. 447.

The displaced head of the bone may rest either on the posterior edge of the glenoid fossa, on the back of the neck of the scapula, beneath the posterior angle of the acromion, or, more rarely, on the dorsum of the scapula below the spine. On dissection, the tendon of the subscapularis is generally found to be detached from the lesser tuberosity.

The symptoms vary according to the amount of displacement of the head of the bone, being proportionately more marked as this is farther removed from the glenoid cavity. There is always the flattening of the shoulder and prominence of the acromion, common to all luxations of the humerus. The head of the bone, covered with muscles, forms a marked protuberance on the back of the scapula, immediately under the posterior angle of the acromion; in front, between it and the coracoid process, is a considerable depression. The length of the arm is unaltered, or but slightly increased; it is generally applied closely to the side, and rotated inwards, with the elbow usually

Fig. 108.



Subspinous dislocation. (From a model by Mr. Flower, in the Middlesex Hospital Museum.)

advanced. The most frequent causes of dislocation backwards, are falls either upon the shoulder, or upon the elbow when advanced. Violent twisting of the arm inwards has produced it, and so has, not unfrequently, convulsive muscular action in a fit of epilepsy.

Partial dislocations.—Sir A. Cooper and most of his contemporaries believed in the existence of these injuries, but many recent surgical authors doubt even the possibility of the head of the humerus being retained in the position indicated by the term 'partial dislocation,' unless under very exceptional circumstances. Malgaigne, rejecting the greater number of cases previously brought forward, as being examples, either of complete luxation, or of pathological changes in the articulation, has described several, which appear to him conclusive instances of 'incomplete subcoracoid dislocation.' But these cases are not, in my opinion, either in their symptoms or post-mortem appearances, sufficiently distinct from the ordinary form of the injury to warrant our placing them in a separate division. I am therefore disposed to agree with Dr. R. Adams in denying 'that the case of partial luxation of the head of the humerus, as the result of accident, has ever been satisfactorily proved, either in the living or the dead subject.'*

Treatment.—The great majority of cases of dislocation of the humerus, when recent, are reduced by the skilful surgeon without difficulty. It is only where the injury is of such long standing that the parts have become rigid, and are beginning to adapt themselves to their new state, or in some of the more unusual positions of the bone, that any mechanical aid need be brought into requisition. The method of treatment which is best adapted for the ordinary forms of scapulo-humeral dislocation will be considered first, and the special modifications required for the rarer varieties will be mentioned afterwards.

The use of chloroform has now superseded all the agents formerly employed to produce a lax condition of those muscles which, by their spasmodic contraction, often present so great an obstacle to the reduction. Whether it is administered or not in any individual case, will depend upon the condition of the patient, and the estimate placed by the surgeon upon the value and the danger of this powerful agent. In recent dislocations, when the patient is of average size and muscularity, it is not usually required, at all events not until after an attempt at reduction by the usual methods has failed, and some more severe means have to be put into operation. In persons of great muscular power, and especially if two or three days have elapsed since the injury, its administration will be advisable. After a longer period, no attempt at reduction should be made without it, not only on account of the saving of pain, but because it renders the chances of success far more favourable.

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* Art. 'Abnormal Conditions of the Shoulder-Joint,' *Cyclop. Anatomy and Physiology*, vol. iv. p. 606.

In very relaxed subjects, especially if it is not the first time of the occurrence of the injury, it sometimes happens that a slight movement of the limb on the part of the surgeon will effect the reduction. Either while lifting the arm from the side or in pressing upon the head of the bone with the fingers in the process of examination, it is felt to go back into its place with a slight snap. But in most cases it is held in its new position with such an amount of firmness as to require that further measures should be taken. Nearly all surgeons who have approached the subject scientifically have agreed, both from reasoning and experiment, that the direction which most favours reduction of the humerus, both by obviating mechanical obstacles and by relaxing the tension of the numerous muscles that pass to it from the scapula, is one in which the axis of the bone shall be a line exactly perpendicular to the surface of the glenoid fossa, which line, if prolonged backwards, is nearly coincident with the lower border of the spine of the scapula. In all the most successful methods of reduction the traction is in reality exercised more or less in this line, although, if the scapula is regarded as a fixed instead of a movable point, it may seem otherwise. But, in fact, so much can this bone turn upon its axis, that, whether in the method of pulling the humerus upwards, advocated by White and La Mothe, horizontally outwards, recommended by Malgaigne, or downwards with the heel in the axilla, so generally adopted by Sir A. Cooper and most surgeons in this country, although the line of traction appears so widely different as regards the body of the patient, yet the two points with which we have specially to deal, viz. the glenoid fossa and head of the humerus, are not far different in their relation to each other. The importance of the mobility of the scapula in facilitating the reduction of dislocations, hitherto much overlooked, has been particularly pointed out by Mr. Skey.*

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* *Operative Surgery*, 2nd edit. 1858, p. 105.

When we have a recent case to deal with, in which we do not anticipate any particular difficulty, we may commence with the following, as the simplest method of reduction. The patient, seated on a chair, may be led to believe that the examination is still going on, so that no extraordinary effort of resistance on his part takes place; for if he is prepared for what he believes must be a serious operation, the muscles are often involuntarily rendered tense. The surgeon, standing behind or before the patient, as is most convenient, places his left hand upon the shoulder to steady it, and with the other, grasping the arm a little above the elbow (which should be flexed in order to relax the biceps), raises it rather above the horizontal line, giving it a slight rotatory motion inwards, combined with moderate extension; at the same time, with the fingers or thumb of the hand which is placed upon the shoulder, the head of the bone may be pressed backwards and upwards into the glenoid cavity. In this way, dislocations may often be reduced without any assistance. Without altering the position of the patient, the surgeon may gain more power over the humerus by placing his foot upon the side of the chair, and pressing his knee into the axilla, by which means he will get some counter-pressure against the wall of the chest, and firmer leverage, to raise the upper end of the humerus into its place.

In the event of failure by these simple methods, another plan in which, although the direction of the humerus is not quite so advantageous, a very effectual means of counter-extension is obtained, and which also has the merit of requiring no assistance, may be tried. The patient is placed upon his back upon a couch, and the surgeon, seated by the affected side, places his heel (the boot being removed) well up into the axilla, pressing upon the lower border of the scapula; grasping with both hands the lower part of the fore-arm, and leaning himself backwards, he draws the limb steadily downwards; the heel being at the same time made to press the head of the bone outwards. Directly it is felt to slip back into the socket, the extension should cease, and the fore-arm be brought across the chest.

If the humerus still resists, the following plan, which I have never known to fail in a recent dislocation, may be tried. The patient is seated on a high chair, which is placed about two feet from the post of an open doorway. The surgeon, leaning his back against the door-post, places one foot upon the side cf the chair, and, with his knee pressed into the axilla, and both hands upon the shoulder, steadies the patient's body. A jack-towel is then fixed by a clove-hitch knot to the patient's arm, just above the elbow; and by its means two or more assistants, placed on the other side of the doorway, make steady extension horizontally outwards. Counter-extension from the opposite wrist has been advocated in America.*

It is scarcely necessary to say, that in all cases the traction must be gradual, steady, and continued, never violent or sudden; and as these conditions can be obtained more surely by means of the pulleys than by the exertions of assistants, in old-standing cases, where not only the resistance of muscular spasm has to be overcome, but fibrous adhesions have also to be broken down, it will be necessary to resort to these aids. The extending power is fastened either to the lower end of the humerus or to the fore-arm just above the wrist, and the shoulder is fixed by towels or straps passed under the axilla, and made fast to a staple in the wall. As the usual arrangements for counter-extension have the great disadvantage of compressing the walls of the axilla, and so making tension upon the pectoralis major and latissimus dorsi muscles, which ought to be relaxed, Mr. Skey employs a well-padded iron knob, from which two strong branches of the same metal extend laterally, each about four inches in length, ending in a bulb or ring, the office of which is to keep the margins of the axilla as free from pressure as possible, and to which the cords from the staples are attached; the iron knob is passed high into the axilla, and acts as the heel in the ordinary operation.†

In a case of twenty-five days' standing, which resisted all attempts at reduction by extension, Mr. Cock, at Guy's Hospital, adopted the following plan: 'an air-pad made of vulcanised india-rubber was placed in the axilla, and the arm firmly bandaged to the side; the air-pad thus being made to exert a powerful outward pressure upon the head of the bone. Upon removing the bandage upon the third day, the head of the bone was found to have returned to its natural position.‡

Dislocations downwards or backwards may be reduced upon much the same principles as those under the coracoid process;

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* See F. H. Hamilton, op. cit. p. 546.

† See figure in Skey's *Operative Surgery*, 2nd edit. p. 106.

‡ Bryant, *Diseases and Injuries of Joints*, 1859, p. 227.

in the latter case the traction should be made in a somewhat forward direction. The true subclavicular dislocation is the most difficult to manage, and has sometimes resisted every attempt at reduction, even in the hands of the most experienced surgeons. To disengage the head of the humerus from the coracoid process, it will have to be drawn downwards and forwards.

When reduction has been accomplished, the joint should be kept at rest for two or three weeks, the arm being placed in a sling with the elbow lightly bound to the side, and all violent exercise prohibited for several months, as a comparatively slight cause may produce a second dislocation. Hamilton, who has given us many valuable observations upon the results of dislocations, makes the remark, that 'the head of the humerus sometimes remains for a long time after the reduction has been effected, slightly advanced in its socket, so as to lead to a suspicion that it is not properly reduced;' and states that the probable explanation of this circumstance is, that 'the long head of the biceps has been broken or displaced.'* I think that it should be attributed rather to injury of the posterior scapular muscles, which, as before mentioned, suffer more frequently than the tendon of the biceps.

In cases that have been neglected it often becomes a question whether we are justified in attempting a reduction, or whether the head of the bone should be left with the new connections it has formed, undisturbed. On this point the surgeon must exercise his judgment in each particular case; but, as a general rule, the limit laid down by Sir A. Cooper, of twelve weeks, may be taken as a guide. Many surgeons have, indeed, ventured much farther, and cases are reported of successful reductions after twelve, and even eighteen, months; but it must not be forgotten that we know less than we should do of the serious accidents which have often attended such attempts, one of the most frequent of which is laceration of the axillary artery. Already a considerable list of fatal cases from this cause might be collected.†

A case of this kind was published by Mr. Callender, in the 2nd volume of *St. Bartholomew's Hospital Reports*, 1866, p. 96. A gardener fell from a roof to the ground, and dislocated his left humerus. The dislocation was reduced, but was afterwards reproduced by an incautious movement of the arm. At the end of the sixth week he was sent into the hospital, where the head of the humerus was plainly felt in the axilla, drawn up towards the coracoid process. It was reduced, under chloroform, with the exercise of very slight force, by circumducting the arm. Directly afterwards a swelling rapidly rising and projecting the pectoral muscle was noticed, and as it did not pulsate and the radial pulse beat naturally, it was thought that the swelling might be due to the rupture of a vein or of a muscular artery. As the swelling continued to increase and the limb was greatly ecchymosed, it was laid freely open, and after turning out a large quantity of clot, a stream of arterial blood was seen to issue from a small round hole in the upper wall of the axillary artery. This vessel was tied above and below the orifice. Gangrene of the limb ensued, and the man died with symptoms of pulmonary embolism.

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* Op. cit. p. 569.

† See Hamilton, op. cit. p. 554.

Compound dislocation at the shoulder-joint is extremely rare, although cases have been met with in which the head of the humerus has been driven through the skin. It still remains to be determined by experience, whether under such circumstances reduction, or resection of the head of the bone, is the safer method of treatment. The latter practice is most likely to be followed by success, if we may draw inferences from the results that have been obtained by its adoption in similar injuries to other articulations.

When fracture of the shaft accompanies dislocation of the head of the humerus, the bone should be firmly put up in straight splints, and chloroform being administered, reduction should be attempted by the usual methods. Dislocations combined with fractures of the neck are often impossible to reduce, and, as several preparations in our museums show, they then terminate either in union in the new position, or in the formation of a false joint between the fractured ends—in either case accompanied by shortening of the limb. Since the introduction of chloroform, however, more favourable results have been obtained in these cases; for when the muscles are thoroughly relaxed, and gentle extension is made on the shaft, the head of the bone can often be manipulated back into its socket. Then it must be fixed by a pad in the axilla and a gutta-percha splint over the shoulder, before the recovery of the patient from the anæsthetic allows the muscles to resume their spasmodic contractions.

Among the rarer complications of dislocated humerus may be mentioned rupture of the axillary artery, of which a case is related by Dr. R. Adams. It was recognised by the diffused aneurismal swelling in the axilla, and absence of pulse at the wrist. After the dislocation was reduced, the subclavian artery was tied, and the patient recovered.*

Occasionally both humeri are dislocated at the same time. A man was brought recently to the Middlesex Hospital, to whom this had occurred in falling into a cellar, with both arms stretched out before him.

Dislocations of the Ulna and Radius at the Elbow-joint.

Though dislocation of the humerus rarely occurs before the age of twenty, the bones of the fore-arm are especially liable to this accident in childhood and youth. More than one-half of the cases of dislocation at the elbow, in the statistical table at p. 764, occurred in boys between the age of five and fifteen. Of thirty-three cases observed by Dr. F. H. Hamilton, nineteen were in children under fourteen years of age.

Malgaigne concludes, from experiments upon the dead subject, and from careful examination and interrogation of patients who have met with this accident, that the most frequent cause of nearly every form of luxation at the elbow-joint, is a twist given to the ulna, which brings the coronoid process successively inwards, downwards, and backwards, and which may be produced by a fall upon either the internal border of the fore-arm, or the inner side of the olecranon. Other authors state that this injury is more frequently occasioned by a fall in which the palm of the hand comes into violent contact with the ground, so that the fore-arm is driven directly back under the lower end of the humerus.

The bones may be displaced backwards, forwards, or to either side; besides these, there may be intermediate forms, as backwards and outwards, backwards and inwards. Each form may be incomplete, or complete; and as exceedingly rare varieties may be mentioned, dislocation of the ulna alone backwards, the radius remaining in its normal situation, and a dislocation of both ulna and radius, in which the former is displaced backwards and the latter forwards, with reference to the lower end of the humerus. There may also be the complication of fracture of the olecranon or coronoid process of the ulna, of either of the condyles of the humerus, or of the head of the radius, or the dislocation may be compound. Much swelling of the arm often follows these accidents, frequently masking their special characters, and rendering it difficult to establish an accurate diagnosis.

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* *Cyclop. Anat. and Phys.* art. 'Shoulder, Abnormal Conditions of,' p. 616.

The only one of the above-named varieties which is at all common, is *dislocation of both bones of the fore-arm backwards.* When this is complete, the coronoid process (if not fractured) is lodged in the olecranon fossa of the humerus. According to Malgaigne, this condition is not so common as the incomplete form, in which the process rests upon the trochlea of the humerus. The radius almost always maintains its relative position to the ulna, being held by the orbicular ligament. The anterior and two lateral ligaments of the elbow-joint are generally torn.

The following symptoms accompany dislocation backwards, when in its most complete and characteristic form. The whole arm appears shortened. The fore-arm is slightly flexed and pronated; it can be moved from side to side upon the humerus if that bone be fixed. The elbow exhibits a marked deformity, being increased in its antero-posterior diameter. The olecranon is carried backwards and upwards, so that its point is above the condyles of the humerus; the tendon of the triceps attached to it is rendered very prominent. On the external side the head of the radius, carried entirely behind the humerus, can be recognised rolling upon the ulna when the hand is rotated. Anteriorly the lower end of the humerus forms a prominence, over which the tendons of the biceps and of the brachialis anticus muscle are stretched.

The various *lateral* displacements may readily be recognised by the deformity of the elbow occasioned by the new relations of the bones to each other. Dislocation outwards is much more frequent than in the opposite direction.

The luxation *forwards* is extremely rare, and yet it has been met with, both in the incomplete and complete form; in the former the summit of the olecranon rests against the inferior part of the trochlea of the humerus, and the radius is below and somewhat separated from the external condyle; the prominence of the olecranon posteriorly has disappeared, and on each side the condyles of the humerus are unusually prominent, with a depression below them; the arm is elongated. In the complete dislocation all the above characters are present in a more marked degree.

Treatment.—The reduction of dislocations at the elbow-joint is not generally attended with much difficulty, and, with slight modifications, which will readily suggest themselves to the surgeon upon consideration of the anatomy of the joint, is conducted on the same principle for all the varieties. The method recommended by Sir A. Cooper, and which is generally adopted, is as follows: the patient sits upon a chair, and the surgeon, resting his foot upon the edge of the seat, places his knee upon the inner side of the elbow-joint, while he grasps the wrist with his hands; he then bends the elbow slowly, but forcibly, at the same time pressing with his knee upon the upper part of the ulna and radius, so as to disengage their articular surfaces from the lower end of the humerus. This method has the advantage of not requiring an assistant; but where help can be procured, extension of the fore-arm directly downwards, as advocated by Mr. Skey, is to be preferred: one person holds the upper arm, while one or more pull steadily at the wrist, and as soon as the coronoid process is brought below the level of the trochlea of the humerus, the action of the muscles bearing upon it, causes it to slip up into its natural place. The after-treatment consists in keeping the arm in the bent position in a sling for two or three weeks, adopting the usual methods for preventing too great inflammatory action, and cautiously commencing passive motion in ten or fourteen days. If as much as a month or six weeks have been allowed to elapse before reduction, great difficulties will be met with. There are, however, cases on record in which it has been successfully performed after five or six months. On the other hand, frequent failures, severe accidents, and even death have been the consequences of such attempts.

In *compound dislocations* at the elbow-joint, if there be extensive laceration of the soft parts, with lesion of the great vessels and nerves of the limb, amputation may be required. In most cases, however, it will be only necessary to enlarge the wound, to remove the articular ends of the bones, and trust to the formation of a fibrous joint. Although these are the rules for the treatment of such injuries generally laid down in modern surgical works, there are certainly cases in which neither of the above proceedings are necessary. If the patient is of healthy constitution, and the external wound not large, nor accompanied by any great amount of contusion, reduction may be effected, the wound closed, and cold water or other antiphlogistics assiduously applied.

In a case thus treated under my care, the patient (a labouring man, aged thirty-four) had fallen from a height of twenty feet upon a boarded floor. The bones of the left fore-arm were dislocated backwards and outwards, and there was a wound between the olecranon and the internal condyle sufficiently large to admit the finger into the joint, and through which a considerable portion of the cartilaginous surface of the trochlea of the humerus could be distinctly seen. But little inflammatory action took place; the wound healed rapidly; in a fortnight passive motion of the elbow was commenced, and in less than two months the use of the joint was perfectly restored.*

For further observations upon the treatment of injuries of the elbow-joint complicated with wound, see p. 761.

Dislocations of the Head of the Radius.

The head of the radius is sometimes displaced from its connections with the lesser sigmoid notch of the ulna, and the capitellum of the humerus. This injury usually occurs at an early age, and has been observed even in very young infants. The causes are, either a fall in which the palm of the hand, coming in violent contact with the ground, communicates the shock to the radius in such a manner as to cause the upper end to start from its attachments, or a fall upon the elbow itself, or a violent pull on the radius, as when young children are suddenly lifted off the ground by the hand.

The head of the radius may be displaced in either of three directions—forwards, backwards, and outwards; the first by far the most common, the last extremely rare. In any of these the displacement may be complete or incomplete; in the former condition, the orbicular ligament appears always to be ruptured; in the latter, it may be only stretched.

In the dislocations *forwards*, the head of the radius lies on the front of the external condyle of the humerus. The following are the most characteristic symptoms. The fore-arm is fixed in a slightly flexed state, either prone or midway between supination and pronation. Bending of the elbow is prevented by the head of the radius coming in contact with the front of the humerus, and complete extension causes pain. The head can be defined in its new position, and when the hand is rotated, it will be felt to move. The whole fore-arm has a peculiar and characteristic twist, occasioned by the altered situation of the upper end of the radius

Dislocations backwards, or outwards, are distinguished by the head of the bone being felt subcutaneously in these positions. They are often accompanied by fracture of the external condyle.

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* See *Lancet*, 1860, vol. ii. p. 360.

Treatment.—Whatever be the nature of the displacement, direct extension from the hand will be found the most efficient means of reduction, combined, if necessary, with pressure by the fingers upon the projecting head of the bone in the required direction. The arm should then be put up in a gutta-percha splint. If, in consequence of the rupture of the annular ligament, there is difficulty in maintaining the head of the radius in its place, a firm pad must be fixed upon it. After dislocation forwards, caution must be used in straightening the arm for the first time; for if the ligaments are not perfectly united, the action of the biceps upon the radius may reproduce the displacement.

Dislocation of the Lower End of the Radius from the Ulna.

Sir A. Cooper, Malgaigne, and Hamilton, describe this injury as a dislocation of the lower end of the ulna from the radius; but, following the analogy of the nomenclature commonly received in other cases, it is preferable to call it, with Desault and Skey, a dislocation of the radius. The ulna is the fixed bone, the radius moves upon it; and it is by an abnormal increase of the natural motion of this bone that the displacement is produced. It may be caused by any injury which produces excessive pronation or supination of the hand; in the former case, the radius is dislocated forwards, the hand accompanies it, and the lower end of the ulna projects prominently backwards beneath the integument: this is rather the more common of the two; in the other the position of the bones is reversed. This luxation is not unfrequently accompanied by fracture of the radius, and cases are recorded in which the styloid process of the ulna has been thrust completely through the skin.

In whichever direction the dislocation has taken place, it is to be reduced by extending the hand, and pressing the radius and ulna into their natural relations to each other. They must then be retained by a compress, and straight splints should be applied for a time to the dorsal and palmar surfaces of the wrist.

Dislocations of the Wrist.

Dislocation of the hand from the lower end of the radius and ulna, though described by all surgical authors, from the time of

Hippocrates till the commencement of the present century, as of frequent occurrence, is now known to be an extremely rare injury. Fractures of the inferior extremities of the bones of the fore-arm were generally mistaken for it, an error which was pointed out first by Pouteau, but more fully by Dupuytren. When it does occur, it is usually compound, or is associated with fracture of some portion of the lower end of the radius or ulna. A fall upon the hand is the common cause of this injury.

The displacement may be in either of two directions, backwards or forwards. In the dislocation *backwards*, the whole hand is placed on a plane posterior to the fore-arm; the upper end of the carpus forms a prominence on the dorsum of the wrist, and the lower end of the radius and ulna project on the palmar surface. The chief diagnostic mark between this injury and fracture of the lower ends of both bones of the fore-arm is derived from carefully noting the position of the styloid process of the radius and ulna, which in the one case will remain with the fore-arm, and in the other be carried backwards with the hand. Measurement also along the back of the hand, from the upper part of the carpal projection to the end of the middle metacarpal bone, in dislocation will give only the length of the carpus and metacarpus of the opposite side, while in fracture there will be at least an additional half-inch belonging to the separated fragments of the bones of the fore-arm Now that the pathology and symptoms of fracture of the lower end of the radius alone are so well understood, there will be no probability of its ever being confounded with a luxation of the carpus. (See pp. 795 et sqq.)

In dislocation *forwards* the hand is displaced to the palmar side, and the inferior extremities of the radius and ulna form a well-marked projection upon the dorsum. This accident is one of excessively rare occurrence, although in the malformations known as ‘congenital dislocations’ of the wrist, the displacement is far more frequently in this direction than in the other.

Treatment.—Reduction is effected by simple extension, aided by pressure upon the carpus in the required direction. The hand should then be suspended in a sling until the ruptured ligaments have reunited; splints may be used if there is any difficulty in retaining the bones in good position.

Dislocations of the Bones of the Carpus.

The head of the os magnum occasionally suffers a partial luxation from the cavity formed for it by the scaphoid and semilunar bones. This is caused by violent flexion of the wrist, as in a fall upon the back of the hand. The unnatural projection on the dorsum of the carpus is easily recognised, and the bone may be pressed back into place, though it is retained with difficulty. A firm compress must be worn over it for some time.

Similar dislocations of some of the other carpal bones have been met with. Erichsen records cases of this injury to the semilunar and to the pisiform bone. The latter 'was displaced by an effort to lift a heavy weight, and drawn up the arm to a distance of nearly an inch by the flexor carpi ulnaris.'[*]

In the Museum of St. George's Hospital is a curious specimen of compound dislocation of the semilunar bones of both sides, occasioned by a fall upon the hands from a great height. The bones were completely forced from their situation, through a wound on the anterior surface of the wrist, one of them merely hanging by a small shred of ligament.

A case is reported by Maisonneuve of simple dislocation backwards of the second row of carpal bones from the first, caused by a fall from a height of forty feet. The nature of the injury was verified by dissection.[†]

Dislocations of the Thumb.

Dislocations of the bones which compose this member are by no means unfrequent, as it is much exposed to injury in falls upon the hand. They may take place at either of its three articulations, and be either backwards or forwards, the former being by far the most common.

1. *Dislocation of the first bone of the thumb* (*metacarpal*) *from the os trapezium.*—This is less common than that of either of the other bones; it has been met with in both directions, and has generally been reduced without much difficulty by simple extension, though splints are sometimes required to maintain the bone in position. It may be mentioned here that a very few cases are on record of a partial luxation backwards of the proximal ends of some of the other metacarpal bones. F. H. Hamilton met with two; both produced in striking a blow with the clenched fist, and in each of which the bones corresponding to the index and middle fingers were affected.[‡]

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[*] Op. cit. p. 281.

[†] *Mém. de la Soc. de Chirurg.* tome ii.

[‡] Op. cit. p. 607.

2. *Dislocation of the first phalanx from the metacarpal bone.*—This injury is of more frequent occurrence; it is usually in the backward direction, *i.e.* the proximal end of the first phalanx lies on the dorsal surface of the distal end of the metacarpal bone. The deformity of the articulation is so well marked, that the diagnosis is unattended with difficulty. The cause is generally either a fall or blow upon the end or the palmar surface of the thumb.

Treatment.—In many cases reduction is effected without any great difficulty, either by seizing the phalanx with the thumb and finger and making extension, or by forcibly bending it backwards and pressing upon the displaced extremity with the thumbs, while the flexor brevis pollicis is relaxed by flexing the metacarpal bone as much as possible into the palm. If these methods do not suffice, greater extending power may be gained by fixing a piece of tape or strong twine round the phalanx, by a clove-hitch knot, a wetted bandage or strip of adhesive plaster having been previously applied to protect the skin.

After a fair trial of all the above measures, reduction has still been unaccomplished in so many cases, that both the cause of the difficulty and the means by which it ought to be overcome have become a standard subject for research and speculation among surgeons of all countries. It will suffice here to say that, although much difference of opinion has certainly existed upon this point, the majority of writers have agreed that the flexor brevis pollicis muscle is in some way the chief obstacle to reduction. Dissection of dislocations artificially produced on the dead subject, shows that when the phalanx is completely carried on to the dorsal surface of the metacarpal bone, the two attachments of the flexor brevis, with their contained sesamoid bones, slip over its wide head, and tightly embrace its neck. It is evident that the bone can only be disengaged from this situation with difficulty. The only successful way hitherto devised to overcome this, is the subcutaneous section of one, or even both of the tendons of the muscle. The cause of occasional failure of even this somewhat severe proceeding is, I believe, the difficulty of effecting a complete division of all the opposing fibres. I have found, in the dead subject, that a division of the fascia which connects together the two sesamoid bones, by allowing the tendons to separate from each other, quite up to their insertion, materially facilitates reduction, without resorting to the section of the muscle itself; but I have not yet had an opportunity of trying this on the living. Dr. Humphry, also on anatomical grounds, recommends an endeavour to draw the sesamoid bones forwards, by means of blunt hooks inserted through an incision in the skin.*

In dislocation of the first phalanx forwards, reduction has always been easily accomplished, generally by forcibly flexing the thumb towards the palm.

3. *Dislocation of the ungual phalanx.*—In this case the principal obstacle to reduction is the difficulty of getting a firm hold of the small displaced bone. Pressing its projecting proximal extremity forwards with the two thumbs will often reduce it, or the tape may be applied immediately above it, and then extension made, or it may sometimes be returned to its place by forcible flexion. Hamilton recommends 'forced dorsal flexion in the case of the backward luxation, and forced palmar flexion in the case of the forward dislocation.'

Dislocations of the phalanges of the fingers occur less frequently than those of the thumb. They are usually in the backward direction, owing to the mode in which the force is applied in falling on the end of one of the fingers, the most common cause of these accidents. The nature of the injury is readily recognised, and the reduction effected by simple extension applied in the manner recommended for dislocation of the phalanges of the thumb.

W. H. FLOWER, 1860.
J. W. HULKE, 1869.

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* *On the Human Skeleton,* 1858, p. 435.

INJURIES OF THE LOWER EXTREMITY.

THE seriousness of a lesion will depend partly on its nature, partly on its extent, and partly on its locality : in the latter respect, injuries of the extremities must rank in importance after those of the head and trunk, and lesions of the upper extremity after those of the lower.

The circumstances which render an injury of the lower extremity more serious than a similar one in the upper, are the greater size of the limb, and its greater distance from the centre of the circulation ; so that although the mischief to be repaired is greater, the power to repair it is less: this is strikingly illustrated in lacerated and contused wounds of the foot, and in compound fractures of the leg, which are more prone to terminate in mortification than similar injuries of the hand or fore-arm. The suspension of the locomotive functions entailed by injuries to this part of the body, must also exert some influence on the circulation, and a retardative effect on the cure ; while the comfort and occupations of a patient are more seriously interfered with than they would be by a corresponding accident to the upper extremity.

CONTUSIONS.

These may be considered as they affect the soft parts only ; as they affect the bones ; or as they affect both soft and hard tissues.

Contusions of the soft parts.—If the skin and subcutaneous tissues are alone bruised, the symptoms and treatment will be the same as in similar injuries to these tissues elsewhere ; but when the contusion affects the deeper textures, as the muscles, symptoms may arise resembling those of accidents of a totally different nature. This happens especially when the muscles which surround the large joints of the shoulder or hip are injured, which are liable to be confounded with fracture or dislocation in the neighbourhood of those joints.

There can be little doubt that contusions about the hip have not only been mistaken for fracture of the cervix femoris, but have been paraded as examples of bony union having taken place without shortening of the limb. A case recorded in the *Gazette des Hôpitaux*, tome ix., is probably one of these. The patient was a female, sixty-four years of age, who was supposed to have an intracapsular fracture of the neck of the femur, and was treated for that injury; but was discharged at the end of a month perfectly cured, and without lameness. A somewhat similar case came under my notice about two years ago, in which a like mistake had evidently been made. The patient was a young man, twenty-four years of age, who was stated to have had impacted fracture of the neck of the femur; the symptoms immediately after the accident were, it was said, eversion, and shortening of the limb. He was confined to bed for a month, and a Liston's splint kept on; at the end of this time both thighs were of equal length, and perfectly symmetrical, voluntary movements of the limb were perfect, and executed with great force and vigour.

The treatment of these muscular contusions consists in absolute rest of the part in the first instance, and friction of the surface subsequently; nevertheless, as cases of impacted fracture of the cervix femoris have been mistaken for mere contusion, every case of doubt should be treated as a fracture.

Contusions of bone are far more serious than bruises of the soft parts, owing to the possibility of inflammation being set up, with all its consequences—suppuration, caries, necrosis. A blow on the shin may be followed by necrosis of the part struck, or of the entire shaft of the tibia;* a fall on the trochanter, though not severe, is often sufficient, in scrofulous children, to set up destructive disease in the hip-joint; while a similar accident happening to the aged is not unfrequently followed by shortening and eversion of the limb, the result probably of the contusion, and subsequent interstitial absorption of the cancellous tissue of the neck of the femur.

Contusions involving all the structures of the limb are usually of so severe a character as to destroy the vitality of several of its structures. In the majority of such cases, amputation is the only remedy; and it should be carried into execution before the constitutional irritation, which is sure to follow, has made its appearance.

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* See case by author in *Path. Soc. Trans.* vol. xix. p. 346.

SPRAINS AND RUPTURES OF THE MUSCULAR AND FIBROUS STRUCTURES.

Of all the joints of the body, none are perhaps more liable to sprains than those of the ankle. This is sufficiently accounted for by the position and functions of this joint, the small size of its articular surfaces, the great weight the astragalus has to support, and the unyielding nature of the lateral ligaments.

The immediate effects of this accident are pain, an inability to bear any weight on the limb, swelling, and afterwards ecchymosis of the soft parts around the joint; all these symptoms varying in degree and extent according to the amount of injury sustained. The remote effects which may follow this accident, if neglected or improperly treated in the first instance, are permanent lameness, from chronic inflammation of the joint; anchylosis, distortion of the foot, weakness of the ankle from relaxation of its ligaments. The lesions which are met with in sprains of the ankle vary from a slight laceration of the connective tissue, smaller blood-vessels, and a few fibres of the lateral ligaments, to a complete tearing through or detachment of the latter, laceration of the muscles and tendons or displacement of these from their sheaths, rent of the synovial membrane, and temporary dislocation of the foot, with or without fracture of one of the malleoli; indeed, the lesions of a severe sprain differ only in degree from those of a dislocation.

Sprains of the ankle are sometimes mistaken for fractures, and the latter for the former; the two injuries may also co-exist.

Sprains of the knee are by no means uncommon, and are characterised by great swelling from the effusion of fluid within the joint. Sprains of the hip and other joints of the lower extremity are less common than those of the ankle and knee, and are not likely to be mistaken for other accidents. The former may, however, resemble incipient hip-joint disease, and may, indeed, lead to its occurrence; but the error of diagnosis, so far as regards treatment, is not of practical importance.

The treatment of sprains of the lower extremity resolved itself into that for diseases of the joints generally, to which the reader is referred. In all severe sprains of the ankle, and in all cases of doubt as to the exact nature and extent of the injury, it should be treated as a fracture, and the 'immovable apparatus,' made with starch, is the best application for this particular lesion: the patient may be allowed to go about on crutches with his leg flexed and suspended at a right angle to the thigh as soon as the apparatus is dry. Laceration or complete rupture of some of the muscles or tendons of the lower limb may take place from violent and sudden contraction or over-stretching of the former, examples of which are most frequently met with in the gastrocnemius and tendo-achillis, the rectus and biceps. A sudden and violent pain in the part, as if struck by a hard body, sometimes accompanied with a sensation of tearing, and with an audible snap, are the symptoms which lead to a suspicion of this injury.

The following is probably an example of this accident. D. B., aged thirty-six, while stooping and exerting all his strength to raise a heavy flagstone, heard a loud snap, and felt a sudden pain about the centre and posterior part of his left thigh; he fell backwards and was unable to rise, and was immediately brought to the Westminster Hospital, where I saw him within one hour of the accident, December 6, 1867, it being supposed to be a fracture of the thigh. All signs of this injury were, however, wanting, except the pain and inability to bear any weight on the limb; he strongly resisted all attempts to flex the thigh, and was incapable of moving it of his own accord. There was no ecchymosis and no numbness of the limb. A long straight splint was applied to the outer side of the limb, which was removed on the 11th, and the patient allowed to go about on crutches. On the 14th he was discharged at his own request. A careful examination of the limb in different positions, failed to detect any injury. There was less muscular resistance on passively flexing the thigh on the pelvis; but pain was still felt at the site of the injury.

A case was under my care a few years ago, in which the right ligamentum patellæ was ruptured from a fall; and two cases of a similar nature are reported by Mr. Shaw in the fifth volume of the *Pathological Society's Transactions*, p. 241, and were produced by causes which usually lead to fractures of the bone.

For fuller information on these injuries, together with the treatment, see the essay on AFFECTIONS OF THE MUSCULAR SYSTEM.

WOUNDS.

There are certain circumstances, dependent on locality, which influence all wounds inflicted on this part of the body. Among those tending to an unfavourable issue, are—1st, the size of the parts wounded, which is more particularly seen in wounds of the blood-vessels and joints; 2ndly, the dependent position of the limb, so that even trifling wounds heal less readily than they would do elsewhere; and lastly, the distance of its extreme parts from the centre of the circulation, which renders them, when injured, more prone to become gangrenous. On the contrary, the facility with which the limb may be placed in any position, or encircled by a ligature, for the purpose of either preventing absorption from a poisoned wound, or arresting hæmorrhage, and the ease with which most of its vessels may be secured when wounded, are so many circumstances which stand in favourable contrast with wounds inflicted on the head or trunk.

Contused and lacerated wounds of the lower extremity most frequently occur in connection with fractures and gun-shot wounds, and are treated of respectively under those heads. When produced by other causes, and unaccompanied by fracture, the only respect in which the treatment would differ from similar wounds in other parts of the body, consists in the necessity of absolute rest of the limb during the greater part of the treatment. Incised wounds of the lower extremity, except when made surgically, are not of very frequent occurrence in civil practice; and, when met with, are generally found to have resulted from some accident in the use of the tools employed in certain trades. Thus the knee-joint may be opened by the slipping of a knife in cutting leather or wood placed between the patient's knees; the femoral artery may also be wounded in a like manner;* and death has been known to result from a wound of this vessel by the breaking of a wine-bottle held between the thighs while drawing the cork. Ugly flesh-wounds are sometimes produced by the scythe in mowing. None of these, however, require any special treatment which is not laid down under the head of WOUNDS OF JOINTS and WOUNDS OF ARTERIES. Punctured wounds of the lower extremity have been observed to be more dangerous when affecting the sole of the foot than either the leg or the thigh; and the danger is increased if the instrument which has caused the wound becomes broken off and buried in the part.

Gross relates the case of a boy, nine years of age, who while running about barefoot, trod upon a chicken-bone, a fragment of which nearly an inch long entered the sole of the foot, lodging deeply in the substance of the flexor muscles, in contact with the metatarsal bones. Pain and swelling followed; but the boy walked about for upwards of a fortnight. Suddenly symptoms of tetanus came on, and though every effort was made, by Professors Gross and Parker, to discover the foreign body, it could not be detected, and death followed a few days afterwards.†

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* See a case reported by the writer in the *British Medical Journal*, 1859, pp. 364, 954.

† Gross, *System of Surgery*, vol. i. p. 373.

Needles, bullets, and other foreign bodies, remain sometimes buried for years in the fleshy parts of the thigh or leg, without causing much inconvenience, and unless their site can be ascertained and they can be conveniently got at, they may be let alone; but when in the neighbourhood of a joint, they are apt to excite recurrent attacks of inflammation, and should be removed.

FRACTURES.

It has been long known that fractures of the limbs are of more frequent occurrence than those of the trunk, but whether the upper or lower limbs are most liable to these accidents is a point not so well determined. Of 1,800 fractures treated at the Pennsylvania Hospital from 1715 to 1838, 901 were of the lower extremity, and 572 of the upper. Of 1,572 fractures at the Calcutta Native Hospital from 1815 to 1837, 681 were of the lower extremity, and 665 of the upper. Of 2,328 fractures collected by Malgaigne from the registers of the Hôtel Dieu at Paris, 1,006 occurred in the lower extremity, and 850 in the upper; giving, therefore, out of the total number of 4,675 fractures of the extremities treated at these three institutions, a majority of 501 to fractures of the lower.* When we take into consideration, however, the fact that many patients with fracture of the upper extremity attend only as casual or out-patients, and so escape registration, it is highly probable that these injuries are quite as numerous, if not more so, than the corresponding ones of the lower extremity. This is quite borne out by the statistics of fractures collected by the late Mr. Lonsdale, at the Middlesex Hospital, between the years 1831 and 1837. During this period there were 1,901 fractures, treated either as in- or as out-patients, and of this number only 516 were of the lower extremity, and 764 of the upper.† These figures probably indicate more correctly than the others the relative proportion of fractures occurring in the two extremities.

Fractures of the Femur.

These fractures, as compared with those of the other bones of the skeleton, stand in the adult, about fifth in the order of frequency; in infancy and childhood about second. Out of

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* Malgaigne, *Traité des Fractures et des Luxations,* tome i.

† Lonsdale, *Practical Treatise on Fractures.*

140 fractures noted by M. Colon at the Hospital St. Eugénie in one year, 38 were of the fore-arm. The next highest numbers were 26 of the femur, and 21 of the clavicle.*

Fractures of the femur may occur in any part of the bone, and include every variety of fracture; but for convenience of description, I shall first treat of fractures of the upper end of the bone; 2ndly of the shaft; and 3rdly of the lower end.

Fractures of the upper end of the femur.—These are divisible into—1, fractures of the neck of the bone within the capsular ligament; 2, fractures of the neck without the capsule; 3, fractures through the trochanter major; and 4, separation of the epiphysis of the head of the bone, and of the trochanter major.

Intracapsular fractures of the femur.—Peculiarities:—1, they nearly always occur in the old; 2, they are more frequent in females; 3, they commonly happen from slight causes; 4, they rarely unite by bone; 5, they usually result in great lameness, and are not unfrequently fatal.

According to Sir A. Cooper, out of 225 cases which he had met with in his practice, only 2 were below the age of 50.† Of 28 specimens of this fracture examined by R. W. Smith, 4 were from persons below the age of 50; 9 from 50 to 60, both inclusive; and the ages of the remainder ranged from 65 to 90, also both inclusive.‡ Exceptions are occasionally met with, and have been recorded by Morgagni,§ who found this fracture in a woman of 40, who had sustained it in her youth; by Stanley,‖ in a lad of 18, and by Hamilton¶ in a girl of 16, and in a man of 25. Neither of the latter were cases of diastasis, for in one 'the direction of the fracture was oblique, commencing just at the articulating surface of the head, and ending just within the capsule.'

Pathology.—Intracapsular fractures of the femur present several varieties, both as regards their situation and direction. The breach of continuity may take place close to the head of the bone, at the point of attachment of the capsular ligament, or at any intermediate part. It may be transverse in direction, more or less oblique, or impacted, the upper end of the lower fragment being usually forced into the cancellous tissue of the upper, or, lastly, there may be a mutual impaction. Much discussion has arisen as to the possibility of partial fractures of the neck occurring; the affirmative being maintained by Colles, Adams and Hamilton, while Robert Smith is 'satisfied that the doctrine has not yet been proved to be correct.' The integrity of the thin stratum of bone which invests the upper surface of the neck in these alleged partial fractures has been attributed by Adams to its having yielded (without breaking), to the force which fractured the lower surface, while Smith is of opinion that the fracture is not visible because 'it traverses the bone exactly where the neck springs from the shaft of the femur.' The annexed figures, though from an extracapsular fracture, illustrate this point. Without committing myself to a positive opinion as to whether some of the alleged examples of partial fracture may not have been cases of complete fracture with slight impaction, I entertain no doubt whatever of the possibility and occasional occurrence of incomplete fracture of the neck of the femur, and the cases published by Tournel[*] as

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* Holmes, *Surgical Treatment of Children's Diseases*

† Sir A. Cooper, *On Dislocations and Fractures of the Joints,* edit. 1842, p. 135.

‡ *Fractures and Dislocations,* by R. W. Smith, p. 108.

§ Morgagni, *De causis et sedibus morborum,* epist. 56, art. 10.

‖ *Med.-Chir. Trans.* vol. xviii. p. 256.

¶ Hamilton, *On Fractures and Dislocations,* 3rd edit. p. 382.

Fig. 109.

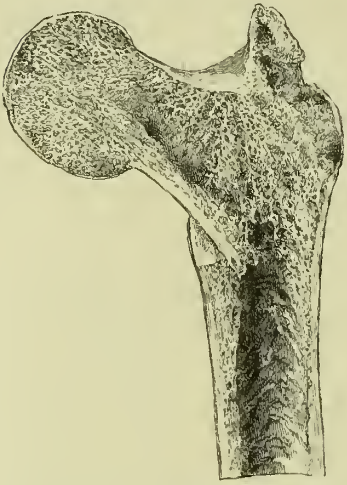
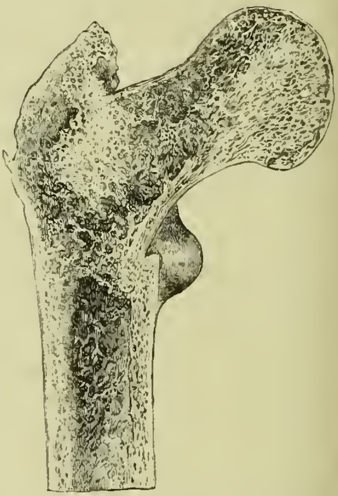


Fig. 110.



Two views of an impacted extracapsular fracture of the cervix femoris, the fracture on the upper surface of the neck not being visible. (From the Museum of the Westminster Hospital.)

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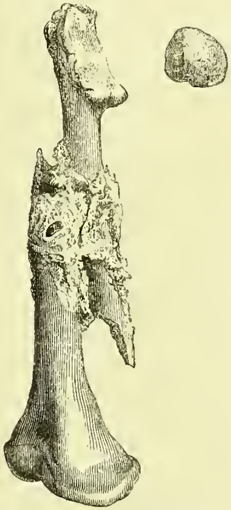
[*] *Archives gén. de. Méd.* 3e série, vol. ii. p. 77.

long ago as 1837, as well as the more recent one of Dr. Jackson,* are incontestable examples of this lesion.

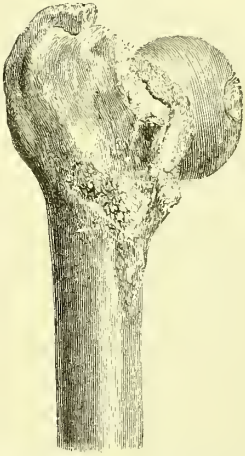
The immediate injury to the soft parts which results from an intracapsular fracture of the femur does not differ from that which occurs in fractures into other joints: the capsular ligament is rarely ruptured, but its cervical reflexion is nearly always torn through, either partially or completely, and the amount of separation of the fragments and of the shortening of the limb are, to a certain degree, regulated by the extent of the laceration: there will be also some blood and an increased quantity of synovia poured into the joint. In old-standing cases, the capsular ligament and synovial membrane are usually much thickened and sometimes partially ossified; sometimes all movement between the fractured surfaces is prevented by their close and firm union by fibrous tissue; or the fragments may be only partially united by elongated bands which allow of the free movement of the lower fragment; or there may be no union

Fig. 111.



False joint after old fracture of the neck of the femur within the capsule. The patient died at the age of ninety-eight, four months after fracture of the shaft of the femur with great displacement. *St. George's Hospital Reports*, vol. iv. (From St. George's Hospital Museum.)

Fig. 112.



Bony union of intracapsular fracture of the femur. (From St. George's Hospital Museum.)

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* *Bost. Med. and Surg. Journal*, vol. iv. p. 351. See also Wilkinson King in *Guy's Hospital Reports*, Oct. 1844.

of any kind, but a false joint, the broken surface of the upper fragment being hollowed out and eburnated, so as to form a socket in which plays the rounded, smooth, eburnated, and shortened stump of the lower fragment;* or each of the surfaces may be concavo-convex, and so adapted to each other as to admit of a considerable amount of motion between them (Fig. 111). Bony union in this fracture is rare, and by some has been considered impossible; but a sufficient number of undoubted cases have now been brought to light both in Europe and America, to place the fact beyond a doubt.† Sir A. Cooper, who first pointed out and fully established this fact, does not deny the possibility of bony union; but he asserts that it requires such a combination of favourable circumstances as is very rarely met with; thus it may take place 'when the fracture is through the head of the bone, with no separation of the fractured ends; when the bone is broken without its periosteum being torn; or when it is broken obliquely, partly within and partly external to the capsular ligament,'‡ and to these we may add when the fragments are impacted, as was the case in the preparation represented in Fig. 112, or when they can be kept in apposition for a sufficient length of time under any other circumstances. Now although it is the separation of the fragments which undoubtedly forms the chief obstacle to union, there are other causes which conspire to the same result; such as the age and feebleness of the patient, and the small supply of blood to the injured parts. 'The head of the bone receives its supply of blood chiefly through the neck and reflected capsule, and when both are severed, the small amount furnished by the round ligament is found to be insufficient.' Lastly, the long confinement in one position, which is necessary for bony union, is what many old people are unable to bear.

Causes.—The immediate causes of an intracapsular fracture are frequently very slight; a common one is slipping off the curb-stone. The sudden jerk breaks the neck of the bone, and the patient falls to the ground; the fall being, in this case, a consequence of the fracture, and not the cause. The injury may, however, ensue from a fall on the great trochanter, or from a sudden movement of rotation of the body while the limb is prevented moving with it. M. Rodet, by a series of experiments on the os femoris, and on plaster casts of the bone, has arrived at the conclusion that the situation and direction of the fracture may be predicated by a knowledge of the direction in which the force has acted. Thus, a force acting vertically will produce an oblique intracapsular fracture; a force acting from before backwards, a transverse intracapsular fracture; one from behind forwards, a fracture partly within and partly without the capsule; and a force applied transversely, a fracture entirely without the capsule.* My experience is confirmatory of the general accuracy of M. Rodet's conclusions.

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* See a case by the writer in *Path. Soc. Trans.* Session 1849–50, p. 252.

† For a full account of the various specimens of bony union, real or supposed, see Hamilton, 3rd edit. p. 355 et seq.

‡ Sir A. Cooper, *On Dislocations and Fractures of the Joints,* edit. 1842, p. 137.

The remote or predisposing causes of fracture of the cervix femoris, and the connection of the accident with old age, are to be sought for in the impaired nutrition, and the altered chemical composition and direction of the neck of the bone which then prevail. It was formerly supposed that the neck had become more brittle through the preponderance of the earthy material of bone, which was known to be relatively increased in all bones as age advanced; but Mr. Bransby Cooper showed that the quantity of bone-earth in the neck of the thigh-bone of the aged was diminished instead of being increased: thus, the average quantity in the necks of five middle-aged bones was 50·1 per cent., in three old bones, 33·5, and in five old bones whose necks had been fractured it was only 23·9 per cent. The shafts of the same bones contained respectively 56·7, 55·5, and 50·1 per cent. of bone-earth.† Too much stress has likewise been laid on the altered direction of the neck of the bone, which, it was affirmed, became less oblique as age advanced, till it formed a right angle with the shaft. Mr. Canton has shown that this is not correct, and that the obliquity of the neck varies very slightly, the few cases in which it has become horizontal being altogether exceptional: the cortex, however, is always thinner, and the cancelli larger, and frequently filled with an oily fat.‡ It is chiefly, then, to the change of nutrition, senile atrophy, with sometimes well-marked fatty degeneration, that must be attributed the greater frequency of fracture of the cervix femoris at this period.

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* *L'Expérience,* 14 mars 1844.

† *Guy's Hospital Reports,* 1845, 2nd series, vol. iii.

‡ Canton, *Surgical and Pathological Observations,* p. 33.

Symptoms.—The symptoms of an intracapsular fracture of the femur may be summarised as follows:—Deformity and loss of power of the limb, crepitus, swelling, and pain.

1. *Deformity.*—This consists of an unnatural prominence of the hip, a fulness of the groin, and a shortening and rotation outwards of the limb; and it is produced by the drawing upwards and rotation outwards of the lower fragment; while the fulness of the groin is partly owing to the broken neck of the femur projecting against the front of the capsule, and partly to effusion within and without the joint. The amount of shortening varies in recent cases from about a quarter of an inch to an inch, and where there is no impaction it can be overcome by making extension. When it is very trifling in the first instance, it may be owing to a temporary paralysis of the muscles from contusion, or to impaction of the fragments, or to the direction of the fracture being such as to oppose the ascent of the lower fragment. It sometimes happens that there is no shortening at first, but that this symptom makes its appearance gradually or suddenly, some days and even weeks after the accident.

Sir Benjamin Brodie dissected a case in which the cervix was obliquely broken, and in which the upper part of the bone prevented the ascent of the lower. Mr. Stanley also relates the following case: 'A man aged sixty was knocked down in the street; he complained of pain in the hip, but there was neither shortening nor eversion of the limb, and its several motions could be executed with perfect freedom and power. A fracture was not suspected; the patient, therefore, was merely confined to his bed. In the fifth week from the date of the accident he died from another cause. No trace of injury was found in the parts around the hip-joint, but small effusions of blood, apparently not recent, were discovered beneath the synovial and fibrous membrane, covering the neck of the femur, also beneath the synovial membrane covering the ligamentum teres. The head and neck of the bone were sawed through their middle, and in each portion a dark line, evidently occasioned by the effusion of blood, was seen extending through the bone at the base of the neck. A fracture was discovered extending along this line; but the broken surfaces were in contact, and the synovial and fibrous membrane covering the neck of the bone was uninjured. In this case,' Mr. Stanley very pertinently remarks, 'if an attempt had been made to walk at the end of two or even three weeks from the accident, a separation of the fractured surfaces, and consequent shortening of the limb, would have been the result.' *

The sudden occurrence of shortening, then, some time after the accident, must be ascribed to the displacement of the fragments, consequent on some movements of the limb which have torn through the hitherto uninjured periosteum of the neck, or unlocked the serrations of the fractured surfaces, or converted a partial into a complete fracture; while the gradual shortening of the limb is owing to the gradual absorption of the neck of the bone.

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* *Medico-Chirurgical Transactions,* vol. xiii. p. 511.

The eversion of the limb, which is often spoken of as eversion of the foot, is really a rotation outwards of the whole limb, so that it rests on its outer surface. This position is given to it by the powerful external rotator muscles of the thigh, aided, no doubt, by the natural inclination of the limb to gravitate in the same direction. The continued eversion which sometimes persists after all muscular resistance has been suspended by the action of anæsthetics, can only be accounted for by the interlocking of the broken extremities of the fractured bone. The occasional occurrence of rotation of the limb inwards may be owing to the fracture having taken place while the limb was in a position of extreme inversion, the fragments having become at the same moment so locked together, as to counteract the action of the external rotator muscles. That the fixation of the limb in inversion is not due to the muscles, is proved by the following fact recorded by R. Smith: if extension be made, so as to remove the deformity and restore the length of the limb, 'as soon as the extending force ceases to act, though the limb is again shortened, the foot will be found to remain everted.'*

2. *Loss of power in the limb.*—When a person has fractured his cervix femoris by a fall, or has fallen in consequence of the fracture, he is usually unable to rise, and should he succeed in doing so, he again falls. There are, however, some notable exceptions, in which patients have not only risen from the ground, but walked after the accident. These peculiarities are difficult to account for; some have attempted to explain them on the supposition of an interlocking of the fragments, others of impaction; and others, again, of the resistance offered by the uninjured periosteum of the neck of the bone; but against all these hypotheses must be placed this fact, that loss of power of the limb sometimes exists without displacement of the fragments, and a considerable amount of power has been observed with displacement. Usually, the want of voluntary power over the limb is complete, and passive movements are attended with pain and difficulty.

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* R. Smith, op. cit. p. 25.

3. *Crepitus.*—This is a symptom which is by no means easily evoked, and its absence does not prove the non-existence of fracture, though its presence is conclusive in its favour. There are several circumstances which may prevent its being felt; one of these is the drawing up of the lower fragment; hence, Sir A. Cooper directs the limb to be first drawn down, and then rotated. But this will not always bring the fractured surfaces together, for the trochanteric fragment may catch on the acetabular one, and push it before it; or the fragments may be impacted and thus move together with the rotation of the limb; or the muscles may strongly resist the efforts of the surgeon to produce crepitus. 'One thing,' observes Hamilton, 'we ought never to forget, namely, that by extraordinary efforts to obtain a crepitus we may lacerate the capsule, or produce a displacement of the fragments which we never can remedy, and which without such unwarrantable manipulation might never have occurred.'

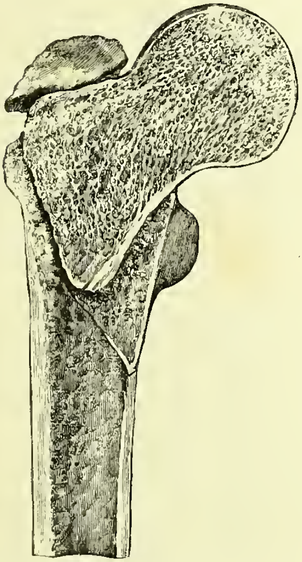
4. *Swelling and pain.*—There is rarely much swelling in this accident, and only a moderate amount of pain, while the limb is at rest; but all movements, especially those of rotation, are attended with considerable suffering. The pain is most felt in the groin and behind the trochanter, and is increased by pressure in these situations.

Fractures of the cervix femoris external to the capsular ligament.—There are three principal types of extracapsular fracture of the femur, depending chiefly on the degree and direction of the force which produced them. In the first and rarest type, the bone is separated into two fragments only, by a fracture which passes through the neck of the bone obliquely at its base, and is bounded above and below by the two trochanters, and anteriorly and posteriorly by the inter-trochanteric lines, with which it is parallel. The fracture may, however, be more horizontal in direction, in which case it will pass through the trochanter major, which will thus be separated into two portions—the upper remaining with the neck of the femur, and the lower with the shaft of that bone. Here too may be placed those oblique fractures of the neck of the femur which have been described by Sir A. Cooper as being partly within and partly without the capsular ligament.

In the second type of fracture, which is, perhaps, the most common, the bone is divided into three fragments: the first formed by the head and neck; the second by the greater part of the trochanter major; and the third by the shaft of the bone and a small portion of the trochanter.*

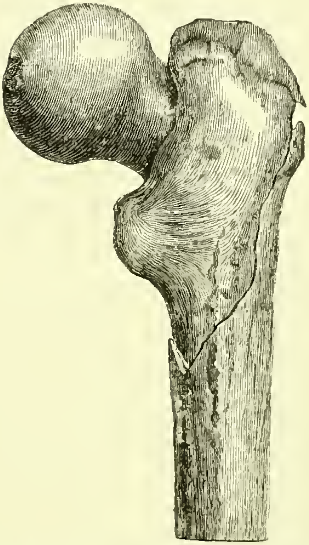
The fracture which separates this process from the other fragments usually begins near the centre of the summit of the great trochanter, passes downwards and inwards, and terminates either above or below, or passes directly through the lesser trochanter. In the third type there is more or less comminution of the trochanteric fragment, and not unfrequently a detachment of the trochanter minor.

Fig. 113.



Extracapsular impacted fracture of cervix femoris with separation of the trochanter. (From the Museum of Westminster Hospital.)

Fig. 114.



Posterior view of the same fracture. (From the Museum of Westminster Hospital.)

Robert Smith expresses his belief that all extracapsular fractures are in the first instance impacted, and that all impacted fractures are necessarily accompanied by a fracture traversing some part of the trochanteric region. This is doubtless true of the majority of extracapsular fractures, but there are some exceptions, as in the specimen referred to by Hamilton in Dr. Matters' collection, where the neck, having been broken close to the inter-trochanteric lines, has apparently slid down upon the shaft about one inch, at which point it is firmly united by bone. So, again, in those specimens of very slight impaction, which have been considered by some as examples of partial fracture,* no trace of anything like a crack or fissure is to be discovered on the trochanter. There is a rare variety of extracapsular fracture occasionally met with, in which the lower fragment penetrates a short distance into the upper.

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* See a very philosophical account of these extracapsular fractures by Dr. Alex. Ogston, in the *Medical Times and Gazette,* May 15, 1869, p. 516.

These extracapsular fractures present a remarkable contrast to the intracapsular in their subsequent progress, inasmuch as bony union is the rule instead of the exception; nevertheless, it is a slow process, and the consolidation of the trochanters to the shaft takes place long before that of the opposed surfaces of the fractured neck and of the shaft. The great exuberance of ossific deposit, which frequently takes place in the neighbourhood of the trochanters, is supposed to have relation to the comminution and separation of the fragments of these processes.

Causes.—The most common cause of the fracture is a fall from a height, or with great violence, on the trochanter major; this first breaks the neck of the bone, which is then driven into the cancellated tissue between the trochanters, and acts like a wedge in splitting, or even detaching entirely, one or both of these processes. The distance to which the neck of the femur is driven into the cancelli of the shaft, as well as the angle which it forms with the latter, varies in accordance with the violence and direction of the applied force.

> 'If the force has not been very great, the neck of the femur remains wedged in between the trochanters, and one or both of these processes are split off from the shaft; but if the fibrous structures before alluded to (which invest the whole of the trochanteric region) have not been injured, these broken portions of the trochanters are still held firmly in their places, and the impacted cervix does not become loosened; but if the force has been considerable, the impulse prolonged, the bone in a state of senile atrophy, or if, as frequently happens, the patient in endeavouring to rise falls a second time, then, under these circumstances, the trochanters are not only broken from the shaft of the femur, but are so far displaced and separated from their connection with the soft parts, that the cavity or socket, as it were, into which the superior fragment has been received, is destroyed. The impacted cervix, thus set free, no longer opposes the ascent of the inferior fragment, and the case then presents the characters of the ordinary extracapsular fracture, with great shortening of the limb.' †

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* See p. 844.

† R. W. Smith, *On Fractures and Dislocations*, p. 17.

Symptoms.—The symptoms of this accident very closely resemble those of an intracapsular fracture. In both there is shortening and rotation outwards of the limb, with more or less loss of power, alteration in the position of the great trochanter (which is nearer the iliac crest and more posterior than natural), occasional crepitus, swelling and pain. At the same time it must be obvious from the foregoing remarks, that the symptoms will vary somewhat in accordance with the impaction or non-impaction, or degree and angle of impaction, of the fragments. It may be stated generally, that the more complete the impaction (using the term strictly in the sense of fixation), the less obvious will be the signs of fracture, and the more liable the injury to be mistaken for one of a different nature; especially will this be the case where the impaction is slight, and the neck deviates but little from its natural angle. On the contrary, in proportion to the separation of the fragments, so will all the symptoms of a fracture of the neck of the bone be more marked, and the nature of the injury less doubtful. Thus the limb may be shortened, from an inch and a half to two inches or more, but can be drawn down to the same length as the other; the rotation outwards will be greater, the crepitus more manifest, the detached trochanteric fragment more displaced, the pain and swelling greater, with sometimes visible bruising of the soft parts about the hip and upper part of the thigh, and complete helplessness of the whole limb. In complete impaction, the shortening of the limb varies from a quarter of an inch to an inch, and cannot be diminished by traction; the eversion is usually less than in non-impacted fracture, and often very slight. Crepitus cannot be elicited by rotating the limb, the head of the bone can be made to move freely in the acetabulum, and the trochanter moves with it, though on a shorter arc. This process is also nearer to the crest of the ilium, and the limb in general lacks that appearance of helplessness which is seen in the other varieties of this accident.

Inversion of the limb, which has been already alluded to as a very rare occurrence in intracapsular fracture, is met with occasionally in fractures without the capsule. In the dissection of these cases it has been observed that the inferior fragment is always in front of the superior; but this is evidently merely the effect, and not the cause, of the inversion. It has also been observed that the direction of the fracture has been such as to detach the posterior part of the great trochanter, and the whole of the lesser trochanter, with their muscles either as a separate fragment, or as a part of the acetabular fragment—thus cutting off the influence of these muscles from the limb. This has been considered sufficient to account for the symptom in question, but against this assumption must be placed the notable facts, that inversion of the limb has been met with where there has been no separation of the trochanters, and that it sometimes occurs, as already stated, in intracapsular fracture. I concur, therefore, in opinion with Professor Smith, that the influence of the muscles in producing inversion is but secondary, the lower fragment being probably thrown by the violence which produced the fracture into a position favourable for the action of the internal rotators. The chief interest attaching to these cases is in a diagnostic point of view, as they are apt to be mistaken for dislocation (see DISLOCATIONS OF THE HIP).

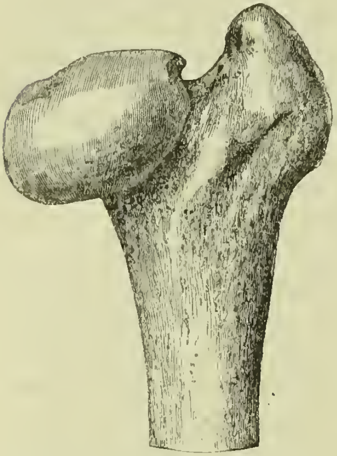
Diagnosis.—The accidents which are most liable to be confounded with fractures of the neck of the femur, are certain fractures of the pelvis—dislocations of the head of the femur upon the pubes—and severe contusion of the hip; while among diseases may be named chronic rheumatic arthritis, absorption of the neck of the thigh-bone, and paralysis. The particular lesions of the pelvis which most nearly resemble fractures of the cervix femoris are fractures of the acetabulum. The bottom of this cavity may be driven into the pelvis, together with the head of the femur; or a portion of its margin may be broken off, so as to allow of the escape of the head of the femur upon the ilium; or lastly, it may be broken without having its fragments displaced. Each of these fractures gives rise to symptoms which, in one case, may resemble a dislocation of the femur; in another, a fracture of the neck of that bone. In the two first there is, in fact, a real dislocation, consequent on the fracture; and it is this complication which renders the true nature of these injuries oftentimes so obscure. Thus there will be shortening of the limb, with inversion or eversion, as the case may be; more frequently the former, and so more nearly resembling a dislocation; but then there will be crepitus, the power of restoring the length of the limb by traction, and the return of the shortening when this is discontinued—all which are characteristic of a fracture. In the fractures of the acetabulum without displacement, the symptoms likewise very closely simulate those of a fracture of the neck of the femur, the absence of shortening of the limb and of crepitus being the only difference; and these symptoms, we have seen, are not always present in this injury. The diagnosis, then, of these several injuries, is by no means easy, though not impossible; and to this we may sometimes be guided by the history of the accident, the age of the patient, and the mixed character of the symptoms. Practically, perhaps, a mistake of diagnosis is of no great moment, as the treatment is nearly the same for all of these accidents, and it may be observed that the real nature of some of them was only discovered after death.

The symptoms by which a dislocation of the head of the femur upon the pubes may be distinguished from the fracture in question, will be pointed out when treating of that dislocation. A severe contusion of the hip more nearly resembles a fracture than would at first sight be imagined; thus, there may be pain, swelling, ecchymosis, eversion of the limb, with loss of power, and altered position of the great trochanter; and, though crepitus and shortening are wanting, we have seen that these symptoms are sometimes wanting in fracture. In all injuries of this ambiguous character, time and rest eventually clear away doubt; still, as prolonged uncertainty is undesirable, chloroform should be administered, and a careful examination made while the patient is under its influence. Should a fracture exist, crepitus may perhaps be elicited, and on the recovery of the patient from the anæsthetic, the limb will probably be found to have become shortened; on the contrary, should the limb preserve its normal length, should its movements be found perfect, and unaccompanied by crepitus, we may infer the non-existence of fracture.

Chronic rheumatic arthritis gives rise to symptoms which very closely resemble those of a fracture of the cervix femoris, as exemplified in the following case: 'A woman of advanced age was admitted into the Richmond Hospital, having sustained an injury of the hip from a fall upon the trochanter. On examination (the patient having been placed in the horizontal posture), the affected limb was found to be one inch shorter than the sound one; the foot was everted; flexing the thigh upon the abdomen caused considerable pain; and the patient was unable to raise the heel from the bed. From these symptoms it was suspected that the neck of the femur had been broken; upon further examination, however, it was found impossible to produce crepitus, or to restore the limb to its natural length by extension; hence it became evident that the case was one either of impacted fracture of the neck of the femur, or of contusion of a joint previously the seat of chronic rheumatism. Upon being questioned, the woman stated that she had for a long period suffered from pain and stiffness in the hip-joint; that the pain was more distressing in wet weather and towards evening, but was relieved by a night's rest; that she had gradually become lame, and had been for some time obliged to make use of a stick when walking. The case was therefore supposed to be one of contusion of the hip-joint combined with chronic rheumatism, and the event proved the correctness of the diagnosis.' *

The change of form which the head and neck of the bone undergo in these cases is well seen in the accompanying engraving. In the above case the history showed that the disease had existed prior to the accident, and the diagnosis was therefore simplified; but it not unfrequently happens that the morbid changes—the interstitial absorption of the neck of the thigh-bone, the alteration of the angle which it forms with the shaft, the flattening and expansion of its head—and the consequent shortening of the limb, and lameness, are first set up by a blow or fall on the great trochanter; and it may become a question at a future time whether the bone was not really broken, the nature of the injury having been overlooked or mistaken. A careful examination shortly after the accident will seldom fail to discover its true nature; but old cases of interstitial absorption of the neck of the femur, following a blow on the trochanter, cannot always be distinguished from old fractures of the same part. Ordinary hemiplegia, or paralysis of the lower extremity, can scarcely be mistaken for a fracture; yet certain cases of infantile paralysis bear some resemblance to it; thus, a child while running about will suddenly fall down and complain of being hurt, and, being put on his feet, it is found he has lost the use of one leg. After a time the limb becomes shortened and everted, and the prominence of the trochanter on that side is diminished. Apart from the rareness of a fracture of the cervix femoris in a young child, it must be remarked that most of the above symptoms only manifest themselves some months after the attack of paralysis, and are the result of atrophy of the limb, which ceases to grow at the

FIG. 115.



Interstitial absorption of the cervix femoris. (From the Museum of Westminster Hospital.)

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* Smith, *On Fractures and Dislocations,* p. 113.

same rate as the sound one. Examined immediately after the fall, it will be found to be simply paralytic, and there will be an absence of all the usual symptoms of fracture. But if certain accidents and diseases bear some resemblance to a fracture of the neck of the femur, so may this injury be sometimes unaccompanied by many of the symptoms which ordinarily characterise it. An example of this was given at page 848, and it may be remembered that the true nature of the lesion was only discovered after death. There are no signs by which such an injury could be recognised during life: the mode in which it happened, the age of the patient, and the pain within the joint, might lead to a suspicion of its nature, but nothing more. Such cases, however, are so rare, that nothing more need be said respecting them; but they suggest great caution in regard to the treatment of doubtful cases.

TABLE TO ASSIST IN THE DIAGNOSIS OF INTRA- AND EXTRACAPSULAR FRACTURES OF THE FEMUR.

Intracapsular Fracture.	Extracapsular Fracture.	Extracapsular Impacted Fracture.
1. Cause.—Often slight or indirect	Falls on the trochanter with great force	Falls on the trochanter with moderate force
2. Age.— Rare before fifty	Not peculiar to, though more common in the aged	Ditto
3. Sex.— More frequent in females.	Relative frequency in males and females not determined	Ditto
4. Shortening.—Not exceeding an inch. Can be removed by moderate extension but recurs when this is remitted	An inch and a half to two and a half Ditto	Not exceeding an inch. Cannot be overcome without using great force
5. Position of the limb.—It rests on its outer side	Ditto	Inclination outwards less
6. Position of trochanter. — Nearer the iliac crest than normal, moves in a smaller arc, head of the bone does not move with it	Nearer the iliac crest, often detached, does not move with the shaft	Nearer the iliac crest, moves with the shaft, and the head of the bone moves with it
7. Crepitus. — Difficult to detect	Crepitus readily detected	None
8. Helplessness.— Great	Ditto	Limb less helpless
9. Pain.—Generally moderate	Often severe	Generally slight
10. Bruising.—Generally none	Frequently evident	Not generally evident

Prognosis.—Whether a fracture of the neck of the femur be situated within or without the capsular ligament, the prognosis must always be guarded; lameness, in a greater or less degree, is inevitable in both varieties; but the danger to life is not small, especially in the extracapsular fractures of the aged, the chief causes of death being shock, irritative fever, or gradual exhaustion of the vital powers.

With reference to the proportion of deaths to recoveries, the tables of the Hôtel Dieu show a mortality of nearly one-third; but this is evidently much too high, and is attributable, according to Malgaigne, to the treatment pursued in that institution. The period at which death ensues will be seen in the following analysis of sixty specimens of fractured cervix, contained in the Museums of the Richmond Hospital and the Richmond School of Medicine, in Dublin, and described by Dr. R. W. Smith. Of these sixty specimens, thirty-two were situated within the capsular ligament, and twenty-eight without, and of the individuals from whom the former were taken,

13 died within 2 months.
10 ,, ,, 1 month.
6 ,, ,, 2 weeks.

Of the subjects of extracapsular fracture,

19 died within 2 months.
17 ,, ,, 1 month.
11 ,, ,, 2 weeks.

The above tables, which are gathered from hospital and workhouse practice, probably give a too unfavourable view of the results of this accident, and if the statistics of private practice could be obtained, it would, I believe, show a more favourable aspect. The union of a fracture of the neck, external to the capsular ligament, takes place quite as readily as that of the shaft of the bone, and provided the age of the patient is not extreme, or the health impaired, or the accident caused by great violence, a more favourable prognosis may be given than the above figures would indicate.

Fractures of the femur through the trochanter major.—'Oblique fractures,' observes Sir A. Cooper, 'sometimes happen through the trochanter major, without implicating the neck of the bone.' 'The first case of this kind I ever saw,' he continues, 'was in St. Thomas's Hospital, about the year 1786. It was supposed to be a fracture of the neck of the thigh-bone within the capsule, and the limb was extended over a pillow rolled under the knee, with splints on each side of the limb, by Mr. Cline's direction. An ossific union succeeded with scarcely any deformity, except that the foot was somewhat everted; and the man walked extremely well. When he was to be discharged from the hospital, a fever attacked him, of which he died; and upon dissection the fracture was found through the trochanter major, and the bone was united with very little deformity; so that his limb would have been equally useful as before.' This fracture appears, from the engraving, to be situated just below the anterior inter-trochanteric line, and to intersect the trochanter near its centre, leaving part of this process connected with the neck of the bone, and the other part with the shaft.

Its distinguishing marks are, 'a fixed state of the upper part of the trochanter, whilst its lower part obeys the motion of the thigh-bone; eversion of the foot, and the very perceptible altered position of the trochanter major; crepitus felt, if a rather free movement be made of the upper part of the limb, and very little diminution of its length. But when the fracture happens below the insertion of the principal rotatory muscles, the lower portion of bone is much raised by the action of the gluteus maximus, and the limb becomes very much shortened and deformed at the place of union by exuberant callus.' The treatment need not differ from that which is proper for fractures of the neck of the femur.

Separation of the epiphysis of the caput femoris.—'Fractures of the neck of the femur,' observes Holmes,* 'are hardly known in childhood, and the upper epiphysis is so small, and lies so completely within the hip-joint, that its disjunction is unknown, except perhaps, in the fœtus.'

Several supposed examples of this accident have, however, been recorded; one by South,† which happened to a boy ten years of age, who had fallen out of a first-floor window upon his left hip. The limb was slightly turned out, but scarcely at all shortened. The thigh could be readily moved in any direction without much pain, but on bending the limb and rotating it outwards, a very distinct dummy sensation was frequently felt, apparently within the joint, as if one articular surface had slipped off another. This was regarded both by Mr. South and Mr. Green, as an example of epiphyseal separation, and he was placed upon a double inclined plane, but he felt so little inconvenience from it, that he several times left his bed and walked about. The result of the treatment is not mentioned. Dr. Post ‡ also relates the case of a girl sixteen years of age, whom he supposed was the subject of this accident. She had a child in her arms, and making a false step, felt something give way, which obliged her to lean against a wall. Dr. Post found the limb an inch shorter than the opposite one; the toes turned outwards, no swelling, but some pain at the upper part of the thigh, the trochanter major moved with the shaft, and there was crepitus. It was put up as a fracture, but a permanent shortening of a quarter to half an inch was the result.

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* Holmes, *Diseases of Childhood*, 2nd edit. p. 258.

† South, note to Chelius's *Surgery*, vol. i. p. 565.

‡ Post, *New York Journ. Med.* vol. iii. p. 190.

Fracture of the epiphysis of the trochanter major.—In the foregoing section it has been shown that a simple fracture may extend through the trochanter major, either from the shaft or the neck of the femur; it has also been shown that this process is generally broken, and sometimes comminuted, in extracapsular fractures of the neck of the bone; the above title, however, would imply that it may be fractured independent of the shaft or neck of the femur, and of this there is certainly not sufficient evidence. The trochanter may, however, be separated from the femur, by violence, at an early period of life, before it has become united with the rest of that bone by osseous matter, as in the following case, communicated to Sir A. Cooper by Mr. Aston Key.

A young girl, about sixteen years of age, in crossing the street tripped, and in falling struck her trochanter violently against the curb-stone. She immediately rose, and, without much pain or difficulty, walked home; but experiencing an increase of pain, she was admitted, five days afterwards, into Guy's Hospital, and was examined by Mr. Key. The right leg, which was the one injured, was considerably everted, and appeared to be about half-an-inch longer than the sound limb. It admitted of passive motion in all directions; but abduction gave her considerable pain. She had perfect command over all the muscles, except the internal rotators. No crepitus, or displacement of bone, could be detected on the closest examination. Nine days after the accident she died. The post-mortem examination revealed a fracture which had detached the trochanter from the body and neck of the bone, but without tearing through the tendons attached to the outer side of the process; this so effectually prevented all motion of the fractured portion that the injury could not have been detected during the life of the patient.

Treatment of fracture of the neck and upper part of the femur.—The fact of the possibility of bony union in intracapsular fractures being established, there are few cases in which it ought not to be attempted, and the treatment applicable to fractures without the capsule is equally proper for those within. The indications are—if the fracture is not impacted—to bring the fragments into as accurate a relation to each other as possible, and to keep them so during the treatment, which should extend over a period of three or four months. There are two ways of doing this, one by the straight splint, by which extension as well as fixation may be caused, and the other by the double inclined plane or fracture bedstead. Mr. Solly, in a clinical lecture published in the *Lancet* of August, 1867, advocates the last-named plan; while Professor Hamilton of New York, prefers the straight position, on the ground that patients can endure this position for a longer time with less suffering than the flexed. Whichever of these methods may be adopted, it must not be forgotten that many old people bear confinement badly: retention of urine is not uncommon, and bed-sores are by no means infrequent. Under these circumstances it may be necessary to abandon all attempts to procure union, and allow the patient to rise daily and get about on crutches, as recommended by Sir A. Cooper. In impacted fractures of the cervix, forcible extension of the limb with the view of restoring it to the same length as the other, must not be attempted, or the fragments may be unlocked, and thus placed in a less favourable condition for union. The long straight splint, used simply as a retentive and not an extending apparatus, is therefore all that is needed in this variety of fracture.

Fractures of the shaft of the femur.—These occur most frequently in its middle third. Of 70 cases observed by the writer, 46 were broken in this situation, 16 in the lower third, and 8 in the upper. Indirect violence occasioned the majority of these fractures; but of those due to direct causes the greatest number, both absolutely and relatively, occurred in the middle third of the bone.

It has been questioned whether a fracture of the shaft of the femur can be produced by muscular action; but of this many instances are on record, in which the production of the fracture cannot be explained in any other manner. Thus Beauchère has given an account of a man, thirty-four years of age, who, while sliding, felt himself in danger of falling backwards, and made a violent effort to keep up; he did not fall, but he heard at the instant a crack high up in the right thigh, which was found to be broken below the trochanters.*

The mode of production of this fracture will influence to a certain extent its character and direction: thus it may be multiple, or comminuted, or compound, if caused by machinery or the passage of a heavy weight over the thigh; transverse in direction, if caused by a sharp blow, and more or less oblique by a fall on the feet, or under a heavy load. The direction and degree of obliquity vary greatly; in the upper third of the bone the prevailing direction, according to Malgaigne, is downwards and inwards; in the middle third of the bone, according to the same author, it is downwards and forwards; while in the lower third, we are assured, it is more prone to assume a transverse direction; and oblique fractures are more rare, and not very constant in direction ; thus, they may run downwards, outwards, and forwards, or downwards and inwards, or downwards and forwards ; or there may be impaction of the upper fragment in the lower. Perhaps the most common direction is downwards and forwards, and the most rare downwards and backwards. In whatever part of the shaft the fracture may be situated, and whatever may be its direction, it is rare that displacement of the fragments does not occur, the lower fragment being drawn upwards, behind, and generally a little to the inner side of the upper ; and sometimes acting upon the latter, so as to cause it to project forwards, or outwards, or inwards, and thus produce more or less angular distortion. This is best seen and most frequently observed when the fracture is situated in the upper third of the bone, and the distortion so occasioned has been attributed to the action of the psoas and iliacus muscles drawing the upper fragment forwards ; but that this is not the sole cause may be easily proved by an examination of the numerous specimens of this fracture in our London museums. From these it will be seen that the displacement of the upper fragment may be in any direction ; outwards, inwards, forwards, or backwards, which could not be the case were its position solely dependent on the action of its own muscles. This is important as respects the treatment of fracture of the femur in its upper third, and the more so because our great authority, Sir Astley Cooper, has omitted all mention of any other distortion than of the upper fragment forwards and upwards, which he attributes to the action of the psoas and iliacus muscles, assisted by the pectineus ; and 'to prevent this horrid distortion, two circumstances,' he says, 'ought to be strictly observed : the one is to elevate the knee very much over the double inclined plane ; and the other to place the patient in a sitting position, supporting him by pillows during

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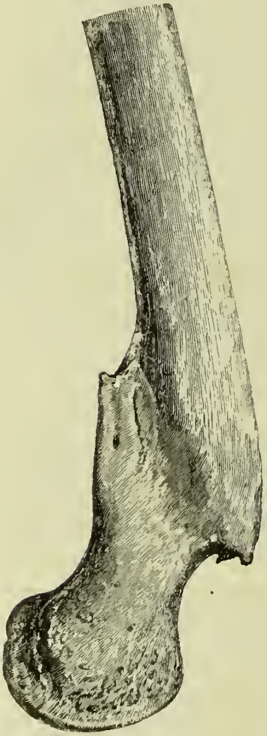
* Beauchère, *Journ. de Méd. de Leroux,* tome xxx. p. 336.

Fig. 116.

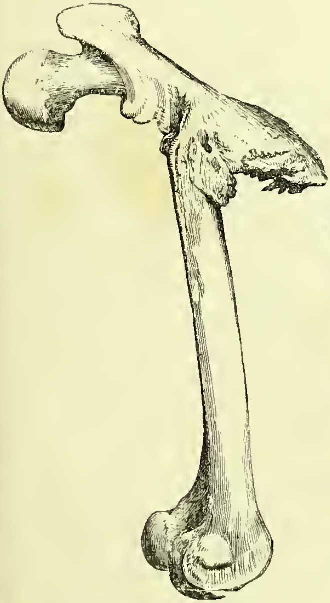


Oblique fracture of the lower third of the femur, downwards and forwards. (From St. George's Hospital Museum.)

the process of union.'* Now the predominant direction of the displacement of the upper fragment is not directly forwards, but outwards and forwards; and the specimen of this fracture which Sir Astley has had figured in his work is an example of the displacement of this fragment directly outwards, a position which has evidently been brought about by the action of the lower fragment upon it; the latter is at the same time rotated one-fourth of a circle outwards, so as to bring its anterior surface to correspond with the external surface of the upper fragment; and hence the apparent projection of the latter forwards and upwards.

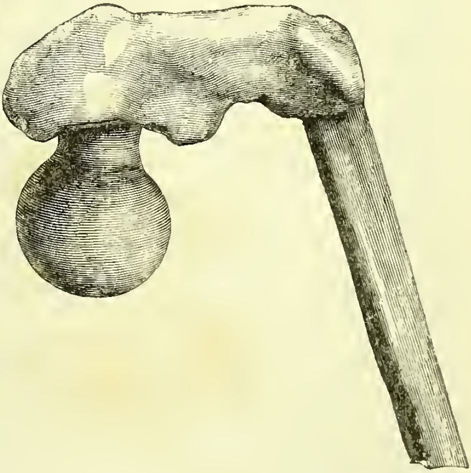
A very fine example of the tilting of the proximal fragment directly upwards is figured below. The specimen was removed from a female brought to the Westminster Hospital for dissection, and is described by Mr. Heath in vol. xi. of the *Pathological Society's Transactions.*

Fig. 117.



Sir A. Cooper's specimen of fracture of the upper third of the femur. (In St. Thomas's Hospital Museum.)

Fig. 118.



Rectangular union of fracture of the upper third of the femur. (From the Museum of Westminster Hospital.)

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[*] Op. cit. p. 191.

Combined with the displacements in the axis of the limb, or at right angles with it, are those by rotation: in a large number of our museum specimens, one or both fragments are seen to have undergone some rotation on their axis; but, in the absence of any history with the greater number of them, it is impossible to say whether such rotation was of the upper fragment, or of the lower, or of both; or how much of it might be due to direct muscular action, and how much to mere physical causes.

Symptoms and diagnosis.—The usual symptoms of a fracture of the shaft of the femur are, shortening and deformity of the thigh, which is generally unnaturally curved, with the convexity forwards and outwards; eversion, and loss of power of the limb; pain, and abnormal mobility at the seat of fracture; and crepitus on rotation. The nature of the injury is so very apparent, that it cannot easily be mistaken for any other; but the determination of the direction of the fracture, whether transverse or oblique, is by no means easy, and not always possible. If the fracture be in a young child, if it have happened from direct violence, if it be situated near the centre of the shaft, and if the shortening of the limb be inconsiderable, the fracture is assumed to be transverse in direction; but a nearer approach to accuracy may be arrived at by attending to the circumstances under which crepitus may be elicited: if this phenomenon can be evoked in a shortened limb, without previous extension, it is presumptive evidence that the fracture is oblique; if, on the contrary, the limb be shortened, and rotation produce no crepitus till it has been restored by extension to its normal length, we may reasonably presume that the fracture is a transverse one.

Prognosis.—The prognosis of a fracture of the shaft of the femur must depend on its nature, the mode of its production, and the age of the patient. If the fracture be compound, or complicated with the wound of a large vessel, or extend into the knee-joint, the prognosis must be guarded, though not absolutely unfavourable. If it occur in an old person, and from great violence, as from a railway-carriage passing over the limb, or if it be compound and communicate with the knee-joint, the case is one of the greatest danger, and the prognosis will be most unfavourable. On the contrary, a simple fracture of the shaft, if properly managed, and uncomplicated with any other injury or disease, will nearly always do well; and though some shortening of the limb usually results, it is insufficient to impair its usefulness, or to cause more than a slight lameness; a favourable prognosis may therefore be given.

Treatment.—Much contrariety of opinion prevails respecting the possibility of curing a fracture of the femur, in the adult, without shortening; and from the time of Hippocrates to the present day, the profession has been ranged in two opposite camps—one side declaring that shortening of the limb may be prevented, and the other as positively denying it.

To determine this question, and without bias either on one side or the other, the writer employed some of his leisure hours in the summer of 1857 in examining all the fractured thighs then under treatment in the different hospitals of this metropolis, till he had procured nearly the same number of cases of this accident from each. To insure accuracy, each limb was measured by a graduated tape from the anterior superior spinous process of the ilium—1st, to the lower border of the patella; 2ndly, to the extremity of the outer malleolus; and 3rdly, to that of the inner; and the result was written down on the spot. The total number of patients thus examined was 50, of whom 41 were males, and 9 were females. Their ages varied from 84 to 2 years; 30 being adults, and 20 children under 15 years of age. Now of the total number, only 15 escaped deformity, and of these 12 were children, leaving, therefore, but 3 adults out of 30 in whom no shortening had taken place, and showing that under the present mode of treating these fractures in the London hospitals, shortening of the limb follows in 90 per cent. of the adults admitted, and in 40 per cent. of the children. Even this high percentage is probably underrated as regards adults; for, in truth, two of the latter in whom no shortening was found were recent admissions, the accident having happened but two days previously in the one case, and four days in the other, rendering it therefore doubtful what the ultimate issue might be: even the single case in which there was no shortening is not free from suspicion, for although the accident had occurred five weeks before, the long splint was still on, and in the absence of examination without it, one could not be sure that the limb had been fractured. The writer's individual experience at the Westminster Hospital is entirely confirmatory of the above results obtained at all the other hospitals; and with the full knowledge of this tendency to shortening in fractures of the femur, and with every attempt to prevent it, he has not yet succeeded in a single case in the adult, nor has he found, in upwards of 100 specimens of this fracture which he has examined in the various museums of the metropolis, more than one in which there was not some shortening. With reference to the amount of shortening in the 35 cases out of the 50 already mentioned, it was—

½ an inch in		4	1¼ to 1½ inches in			4
⅔	” ”	2	2	”	”	3
¾	” ”	10	2½	”	”	1
1	” ”	9	3⅓	”	”	1

and in one it was not ascertained, both thighs being broken.

These results of the writer's own observations are fully confirmed by Malgaigne and Hamilton; the former of whom bears this strong testimony on the subject: 'There has been too much discrepancy of opinion among surgeons in regard to this (shortening). Hippocrates gives the idea that the shortening can always be obviated; Celsus goes to the opposite extreme, declaring that a thigh once broken must ever remain shorter than its fellow. At a period by no means remote from our own, Desault claimed to cure all fractures without shortening, and his journal contains several such cases. In imitation of him, many surgeons have varied, corrected, and improved apparatuses for permanent extension, and have announced as complete successes from them. I must, however, state positively that I have never obtained anything of the kind, either with contrivances of my own, or with those of others, or even when I have invited the inventors of such apparatuses to apply them in my wards. I have more than once examined persons said to be cured without any shortening, but always discovered such shortening by careful measurement. The mistake of all those who have thought they had obtained these miraculous cures was, that they never dreamed of comparing the two limbs in regard to their length; I will say, moreover, that they were most commonly ignorant of the proper way to obtain a good and correct measurement. Some have been deceived in another way; they have lighted upon fractures with interlocking, especially in young subjects, and have imagined that they had corrected by treatment a shortening which never existed. In short, when the fragments remain in contact, or when we can replace them and keep them so by means of their serrations, it is easy to cure a fracture of the femur without shortening; in the absence of these two conditions the thing is simply impossible.' *

Hamilton also states, that 'in case of an oblique fracture of the shaft of the femur occurring to an adult, whose muscles are not paralysed, but which offer the ordinary resistance to extension and counter-extension, and where the ends of the bone have once been completely displaced, no means have yet been devised by which an overlapping and consequent shortening of the end of the broken bone can be prevented.' He also affirms that 'the average shortening in simple fractures, where the best appliances and the utmost skill have been employed, is about three-fourths of an inch.' †

The causes of these different results in the adult and in the child probably depend on the different chemical composition of the bones at these two periods of life, and the modifying influence which this exerts on the form and completeness of the fracture. In the child, too, the periosteum is thicker, and in many cases only partially torn through—or not torn through at all—so that complete displacement of the fragments does not take place.

In the treatment of fractures of the shaft in the adult, three indications should be fulfilled—1, coaptation and fixation of

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* Malgaigne, op. cit. 723.

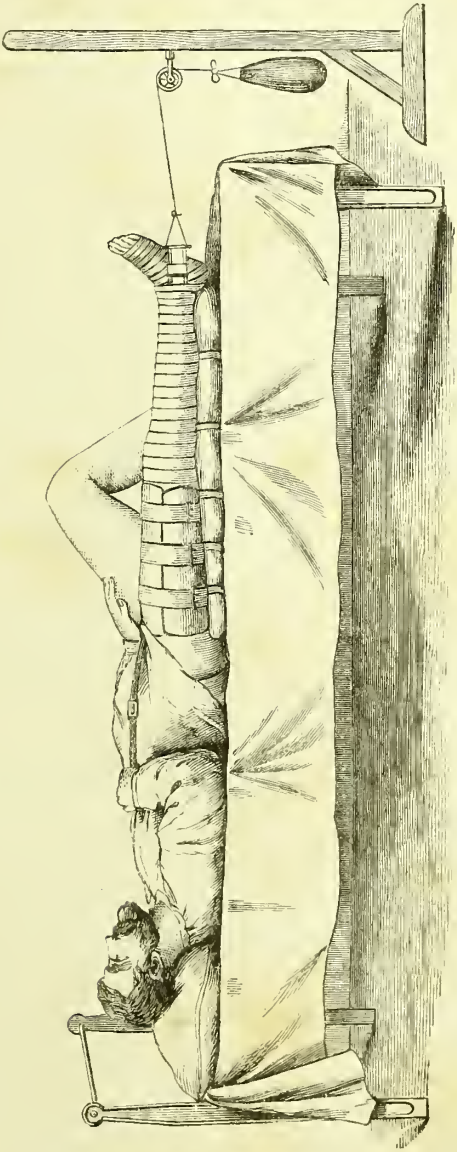
† Hamilton, op. cit. 3rd edit. p. 405. Notwithstanding this strong testimony, surgeons are still to be found hardy enough, or ignorant enough, to repeat the fallacies which have been so often refuted, and to vaunt their success in the cure of oblique fractures in the adult, without shortening. Why do not these surgeons, instead of publishing their cases in the journals, produce their patients at some of the medical societies?

the fragments; 2, moderate extension; and 3, gentle compression and support of the limb. Provided these requirements are carried out, it matters little what apparatus may be employed: but that which can be applied with the least disturbance of the fractured bone, and is most comfortable to the feelings of the patient, should be preferred. The time has gone by when the relative advantages of the straight and of the flexed position are worth discussing, the great majority of surgeons in all parts of the world being agreed on the superiority of the former. Fractures even which were thought pre-eminently to require a flexed position of the limb, as those in the upper third of the thigh, are now usually treated in the straight position. There are three principal ways of doing this: in one it is effected by means of a long splint on the outside of the limb, extending from the axilla to a few inches beyond the foot, as in the splint which goes by the name of Liston's. This provides not only for the immobility of the whole limb and trunk, but acts also as an extending apparatus. The following is the ordinary mode of applying it:—

The patient lying on his back on a firm flat mattress, a few turns of a roller should be first carried round the foot and ankle; then the splint, well padded on its inner side and reaching from a point opposite the nipple to four or five inches beyond the foot, must be laid on the outside of the fractured limb, and firmly secured to the latter by several more turns of the same roller around the foot and ankle and splint, and through the notches at its lower extremity; it may then be carried upwards as high as the knee. At this stage of the proceeding traction should be steadily made on the limb by assistants, till its length equals, or even slightly exceeds, its fellow, as ascertained by measuring with a tape from the anterior superior spinous process of the ilium to the lower border of the patella. When this has been effected, the perineal bandage must be applied, its padded centre resting on the perinæum, and its two ends passed through the holes in the upper part of the splint and tied on its outside. By this means the splint is prevented from ascending, and, by tightening the perineal bandage, it can even be forced downwards, and powerful traction thus exerted on the limb. Lastly, the remainder of the limb should be encircled by the roller, and the upper part of the splint bound to the trunk by a few turns of a broad rib-bandage. This method of treating fractures of the thigh, though so generally adopted, is not free from several grave defects. In the first place, the application of the circular bandage to the limb necessarily involves much handling of the fracture, and consequently, more or less disturbance of the fragments, while at the same time it is next to impossible to keep up sufficient extension during the somewhat tedious process of bandaging from the toes to the trunk. Moreover, however skilfully it may be put on in the first instance, in a few days it becomes loose, and a repetition of the process is necessary. For these reasons I hold it to be preferable to substitute for the roller a sheet or table-cloth, as recommended by Mr. Syme, or towels, or broad bands with buckles, or, indeed, anything which will effectually maintain the splint in position, without making unequal pressure on any part of the limb, and which does not require, during its application or readjustment, the holding up of the limb which is necessitated by the ordinary bandage. The next objection to this method is the perineal bandage, which, if tight enough to keep up effectual traction on the limb, is apt to cause ulceration of the skin in the neighbourhood of the ankle and perinæum, or œdema of the limb by its pressure on the veins of the upper part of the thigh. To obviate this, Hagedorn's splints, as modified by Gibson, may be used, the principle of which consists in having a crutch affixed to the upper end of the splint, whereby the counter-extension is made from the axilla instead of the perinæum. In this apparatus a similar splint is applied to the sound limb, and the lower ends of each pass through a foot-board to which the feet are attached. Or De Morgan's long splint and pulleys may be applied to the opposite limb. This consists of a long, straight, stout splint, with a piece of wood about a foot in length let in at right angles to it about six inches from its lower end. The long arm of the splint is well padded on its inner side. An inch or two from the upper end of the splint is a small pulley, fixed in an aperture made for the purpose; a similar one is placed at the lower end. That part of the splint which is let in at right angles is provided with a slit extending nearly its whole length, admitting another pulley of similar size, which can be shifted to various parts by means of an iron pin passing through holes bored in the sides of the cross-piece. A strong piece of strapping is now applied to the sides of the leg, leaving a loop at the sole of the foot, as in the ordinary way, care being taken that the loop shall be large enough to admit a tightly-rolled leg-bandage;

this being placed transversely at about the middle of the sole of the foot, so that it is enabled to receive all lateral pressure when extension is applied. Without this, the strapping would cut the hollow and outer side of the foot, and give rise to considerable pain and inconvenience. In cases of fracture of the leg, the strapping should not come above the seat of injury.

Fig. 119.



Dr. Gurdon Buck's apparatus for the treatment of fractured thigh.

Mem. The perineal band, which in this drawing (copied from Dr. Gurdon Buck's work), appears to be fixed to the bed on the opposite side to the fracture, should be secured on the injured side.

The foot should now be bandaged, so as to retain the strapping firmly. A piece of strong cord is then fastened to the loop of plaster, so as to include it and the roller, and this gives us a fixed point to pull upon from below. The cord, thus fastened, is next passed over the pulley which lies in the slit in the cross-piece, then over the pulley at the lower end of the splint, and is carried to about the middle of the outside of the long side-piece. Here it is attached to one end of a patent elastic door-spring, or accumulator. To the upper end of the elastic is attached a piece of wood,* about four inches long, one inch broad, and half an inch thick, perforated by three holes equidistant, and just large enough to admit the cord used. By one of these holes, it is secured to the elastic. A well-padded perineal band is now applied, to the upper part of which a separate piece of cord is fastened. This is brought over the pulley at the upper end of the splint, and then made to perforate successively the two remaining holes in the piece of wood attached to the elastic. It will now be evident that, by slipping this piece of wood up the cord fastened to the perineal band, the elastic will be put on the stretch, and, in this way, extension may be regulated to a nicety.

The limb may now be brought into position, and extension applied as far as is deemed proper. In all cases I hold it to be advisable to apply short splints to the thigh; and indispensable to do so when the fracture is in the upper third of the bone.

Dr. Gurdon Buck believes that better results may be obtained when the extension is made by means of a weight and pulley, as seen in the engraving. In this apparatus the long splint is dispensed with, and the thigh only is surrounded with four short splints, while counter-extension is provided for by means of a perineal band, having its two ends made fast to the head of the bedstead. 'The advantages claimed for this method over others heretofore in use, are its great simplicity of arrangement, facility of management, and especially the comfort it affords the patient during a long confinement in bed.' † It is only fair to the late Mr. James of Exeter, to state that he made use of the weight and pulley many years before it was employed in America.

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* Similar to what is used for tightening the ropes of tents. It is used here on the same principle, and was suggested by Mr. De Morgan.

† Description of an Improved Extension Apparatus for the Treatment of Fracture of the Thigh, &c., introduced by Gurdon Buck, M.D., Surgeon to the New York Hospital, St. Luke's Hospital, &c., &c.

The third mode of treating fractures of the thigh in the extended position is by one of the various forms of the so-called immovable apparatus. In spite of their unquestionable value in a large number of fractures, I must dissent from the propriety of their application to recent fractures of the thigh in the adult, on the grounds already stated against the ordinary circular bandage.

As Mr. Erichsen is, I believe, the only London surgeon of note who advocates the employment of the immovable apparatus in recent fractures of the thigh, I here subjoin his directions for applying it. 'The whole limb is enveloped in a layer of cotton-wadding, which is thickly laid along and over the osseous prominences; over this should be laid splints of thick and coarse pasteboard soaked in thin starch, properly shaped to fit the limb, extending beyond, and fixing securely the two joints above and below the fracture: the hip and knee when the thigh is broken; the knee and ankle when the leg is fractured. The pasteboard should be soft, not milled, and be doubled and torn down, *not* cut, as in this way the edges are not left sharp. If much strength be not required, as in children, or in some fractures of the upper extremity, a few slips of brown paper, well starched, may be substituted for the pasteboard. A bandage saturated with thick starch must now be firmly applied; and lastly, this is to be covered by another dry roller, the inner sides of the turns of which may be starched as it is laid on. I always take especial care not to apply any roller or bandage directly to the fractured part under the splints, and always to include in the starched apparatus the two joints that are connected with the broken bone, so that complete immobility of the fragments may be secured. During the application of this apparatus, extension must be kept up by an assistant, so as to hold the fracture in position, and, until the starch is thoroughly dried, which usually takes from thirty to fifty hours, a temporary wooden splint may be applied to the limb, so as to keep it to its proper length and shape.' *

While advocating the straight position for fractures of the thigh generally, I would by no means be understood to deny the occasional propriety of adopting the flexed, and for this any of the many fracture beds in use are preferable to the simple double inclined plane. The bedstead is not intended to supersede the employment of lateral splints, which should extend from the trochanter to the knee on the outer side, and from the perinæum to the same point on the inner, and be firmly secured by straps and buckles.

A few words must be added on the treatment of these fractures in infants and young children. For them it is seldom necessary to do more than encircle the thigh from the knee to the hip with soap-plaster spread upon leather, care being taken that it is not applied too tightly, and that the skin in the perinæum and its neighbourhood is kept dry and clean by changing the napkins the moment they become soiled, and washing the parts from time to time with a solution of alum: a little lapis powder dusted on the parts, or zinc ointment rubbed in, is an excellent preservative against inflammation and excoriation. In older children, splints of leather or gutta-percha or the immovable apparatus may be applied. Whatever plan of treatment may be selected for these fractures, it is essential to bear in mind that the amount of shortening is, to a great extent, within the control of the surgeon; and though he may fail to prevent it altogether, he may greatly diminish it by care and frequent supervision. As respects the duration of the treatment for a simple fracture of the thigh, it will average from two to three months in an adult, and from six weeks to two months in a child. It is by no means necessary that patients should remain in bed all this time; six weeks will generally be long enough for an adult, and four weeks for a child; after which the immovable apparatus should be applied, and they may be allowed to go about on crutches; but they will seldom be able to dispense with all support to the limb under the period mentioned above.

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* Erichsen, *Science and Art of Surgery*, 5th edit. vol. i. p. 242.

In compound fractures, unless both the soft parts and bone are crushed, or the principal blood-vessels or nerves of the limb torn through, or the knee-joint opened, amputation should not be performed; but a long interrupted splint applied on the outer side of the limb, and the wound treated on general principles. In some cases, the long splint may be dispensed with, and even the short thigh splints—extension and counter-extension being provided for by the weight and pulley, and a perineal belt, while inversion or eversion of the foot is prevented by sand-bags placed on each side of the leg. Out of twenty-one cases of compound and comminuted fractures of the thigh, taken indiscriminately and treated in the above manner by Surgeon Van Steinberg, of the 53rd N. Y. S. V., nineteen recovered with tolerably useful limbs.*

Fractures into the knee-joint.—These may involve each or all of the bones entering into the formation of the joint, and the gravity of the accident will be in direct relation to the number of the bones implicated, their degree of comminution, and whether the fracture be simple or compound. Fractures of the femoral part of the joint may be situated either above the condyles or through them; and may be transverse, oblique, or vertical. Not unfrequently they are multiple, the two condyles being detached from the shaft by a transverse fracture, and from each other by a vertical or oblique fracture. The latter also may traverse either condyle, or the intercondyloid space. In young children the epiphysis is sometimes separated from the shaft, and this may be combined with a fracture through one of the condyles.

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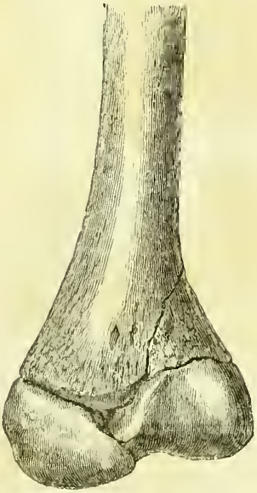
* S. Swinburne, *American Medical Times*, 1863, vol. i. p. 149.

Chips of bone or portions of articular cartilage are also occasionally detached from the condyles into the joint, as in a case recently recorded by Professor Volkmann of Halle, where after a heavy fall on the knee while the limb was in a state of acute flexion, a portion of the cartilage of the inner condyle, measuring nineteen mm. in diameter, was broken off, and gave rise to symptoms of 'loose cartilage.' Between four and five months after the accident this foreign body was extracted by an incision about two-thirds of an inch long, made directly down to it, the skin having been previously displaced so that the skin wound should not afterwards coincide with that into the joint capsule. The limb was put up in a plaster of Paris splint, and the patient recovered without a bad symptom.*

Fractures of the head of the tibia are more rare, and, unless compound, they are not usually dangerous; nevertheless, lameness not unfrequently results from the inflammation which these fractures set up in the knee-joint, and the permanent stiffness which follows.

These injuries are sometimes caused by getting the leg between the spokes of a wheel in motion, by falls on the knee, or by kicks. The nature of the accident is recognised by the mobility of the fragments, the crepitus, the swelling of the joint, and the impossibility of bearing any weight on the limb.

Fig. 120.



Separation of the lower epiphysis of the femur, combined with fracture. (From the Museum of St. George's Hospital.)

No absolute rule can be laid down as to the position in which the limb should be placed in the several varieties of fracture. For the majority, the straight is undoubtedly the best, as the pressure of the articular surfaces on each other insures the juxtaposition of the fragments. In other cases again, it has been found that the fragments could only be kept in place by flexing the leg, and where a vertical or oblique fracture separates the condyles, lateral pressure may also be required. If much inflammation arise, it may be reduced by leeches, fomentations, or evaporating lotions, as most agreeable to the patient's feelings. Passive motion should be commenced in five or six weeks, to prevent anchylosis. In compound fractures into the joint, amputation of the limb will generally be necessary.

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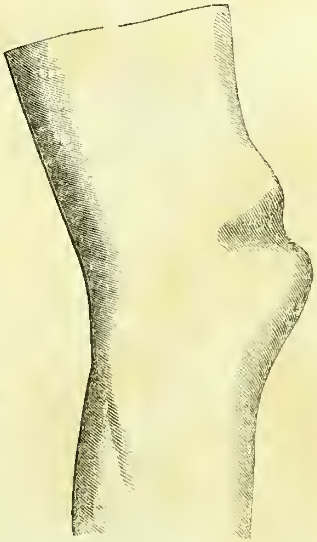
* *Deutsche Klinik,* 1867, p. 448. See also Teale, *Med.-Chir. Trans.* vol. xxxix; Brodhurst, *St. George's Hospital Reports,* ii. p. 141.

Fractures of the Patella.

Fractures of the patella present the same varieties as fractures of other bones; they may be simple, comminuted, or compound; vertical, oblique, or transverse; and are caused either by direct violence, as falls or blows upon the knee, or by muscular action. Of all the bones of the skeleton, the patella is most liable to be broken from the latter cause; and the frequency of its occurrence would imply some peculiarity in the structure or position of this bone. As regards structure, Malgaigne affirms that these fractures are sometimes favoured by an antecedent morbid condition of the bone; but this will not explain their greater relative frequency as regards the other bones of the skeleton, unless it can be shown that the patella is more prone to this morbid change than they are. As respects position, when the knee is slightly bent, the patella is supported upon the condyles of the femur on its transverse axis only, whilst its upper half is unsupported behind, and its superior edge projects slightly upwards. Under these circumstances, a sudden and violent contraction of the extensor muscles of the leg, which are now nearly at right angles with the vertical axis of the patella, may snap the bone in two, as not unfrequently happens when a violent effort is made to prevent oneself falling backwards, or in voluntarily throwing oneself backwards to avoid falling forwards. Fractures of the patella by muscular action are always transverse, or nearly so, and generally take place through the centre of the bone, though they may be above or below it. The frequency of fractures in this direction seems to have led English surgeons to the belief that the majority of fractures of this bone are of muscular origin. This is contrary to the experience of foreign surgeons, who attribute the greatest number of these fractures to direct violence: thus, of nine cases related by Boyer, five were caused by falls on the knee, which accident likewise produced eleven of the nineteen fractures observed by Malgaigne; while of fourteen which came under the observation of Hamilton, thirteen were the result of direct blows or of falls on the knee, and only one was due solely to muscular action. The extent to which the fragments may become separated in transverse fractures of the patella, is subject to considerable variation, and depends chiefly on the mode in which the accident happened. In a fracture from a blow, the patient may not fall down at all; in one from a fall on the knee, he falls forwards or sideways; but in a fracture from muscular action, he falls backwards, with the leg under the thigh. In the two former instances there may be little or no laceration of the fibrous structures attached to the patella, the fragments of which may be only slightly separated; but in the latter, owing to the sudden and violent contraction of the quadriceps, and the forcible flexure of the knee in falling, the soft parts will be more extensively lacerated, and the separation of the fragments correspondingly great. This I believe to be true, as a general rule; but in two patients recently under my care at the same time, the greater separation was in the one in which the fracture had been produced by direct violence.

Fig. 121.



Drawing from a cast of a limb in which the patella had been fractured. (From the Museum of the Westminster Hospital.)

Symptoms and diagnosis.—The symptoms of fracture of the patella are generally well marked; when transverse, the separation of the fragments leaves a depression in front of the joint, into which the fingers may be inserted, and the condyles of the femur readily felt. Above and below this depression, the fragments of the patella may be recognised, and, on bending the knee, the interval between them will be greatly increased. The power of extending the limb, or of bearing any weight upon it, is lost or impaired. In some cases little more than a transverse fissure can be detected, the bone being evidently fractured, but its fragments retained in apposition by the periosteum. In other cases symptoms are present which resemble fracture, though none exists: thus a fall on the knee may tear across the fibrous capsule, and leave a transverse fissure; or a slight effusion into the bursa patellæ sometimes resembles a fracture, or the bursa may become thickened in parts, and so convey to the fingers the sensation of ridges on the surface of the bone. In vertical and comminuted fractures of this bone, the fragments can be easily brought into juxtaposition, and crepitus elicited. All the varieties of this fracture are followed by more or less inflammation in the knee-joint, which not unfrequently becomes greatly distended with fluid, and thus separates still further the broken portions of bone. From this cause I have seen the nature of the injury overlooked, and the case treated as one of synovitis only.

Pathology.—It is rare for a patella which is broken transversely to become united by bone; more frequently the fragments are united by a ligamentous tissue, which varies in length from half an inch to an inch, although it may greatly exceed this, as in a specimen exhibited by the writer at the Pathological Society, figured on opposite page, and where the distance between the fragments is two inches and a half. Not unfrequently, however, the fragments remain ununited, being connected with each other merely by a portion of the fibrous capsule of the knee-joint, thickened, and having incorporated with it the bursa naturally existing on the front of the patella. In this case, the aponeurotic structure may pass either from the periosteal surface of one fragment to that of the other, or it may be reflected over both fractured surfaces; or, what appears to be the most common deviation, it may pass from the periosteal surface of the upper fragment, to the articular edge of the lower, as seen in the engraving (Fig. 123). Of thirty-one specimens examined by Mr. William Adams, to whom we are indebted for these observations, fifteen were examples of ununited fracture, twelve of true ligamentous union, and four were doubtful from their being dried.* In these ununited fractures the fragments may be separated to the extent of five inches, whereas in true ligamentous union, the separation rarely exceeds an inch and a half. Notwithstanding this holds good as a general rule, most surgeons must have met with cases in which good ligamentous union has taken place, the fragments not being more than one-half to three-quarters of an inch apart; yet, after the patient had been going about for a few weeks or months, there has been found a wide interval between them, owing to the gradual yielding or the sudden rupture of the new material.

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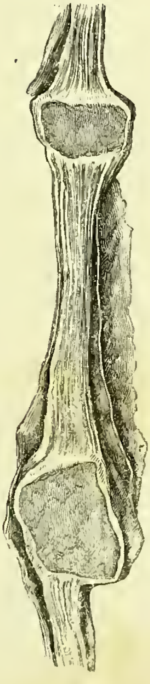
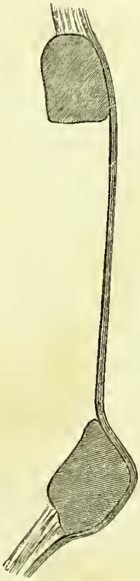
* *Transactions of the Pathological Society of London,* vol. xiii. p. 179.

Fig. 122.



Fracture of the patella, united by ligamentous tissue. (From the Westminster Hospital Museum.)

Fig. 123.



Fracture of the patella; the band of union passing from the periosteal surface of the upper to the articular surface of the lower fragment. (From St. Thomas's Hospital Museum.)

Hamilton examined a patient who had had his patella fractured nine weeks before, and found the fragments united by a short ligament, except on the inner side, where there was a separation or rupture of the ligament to the extent of a quarter of an inch. The patient explained this by saying that the splint was removed at the end of four weeks, and that, after a week more, he began to walk, but that he almost immediately felt it tear or give way on the inner side. Dr. Coale also presented to the Boston Society for Medical Improvement 'a specimen of a fractured patella taken from a man sixty-five years old, the fracture having occurred ten years before. The fragments were at first so closely united that no division between them could be discovered; but subsequently they became separated at their outer edges one inch, and at their inner edges one-eighth of an inch.' *

The great rareness of bony union in transverse fractures of the patella is owing simply to the difficulty of keeping the fragments in sufficiently close apposition; when this is accomplished, bony union occurs as in other fractures.

Treatment.—Three different plans have been adopted in this fracture; one consists in relying simply on the position of the limb, another in the immediate application of apparatus for bringing together the fragments, and a third in trusting to position only for the first ten or fourteen days, and then applying some approximative apparatus for the remainder of the period. The chief objection to the first plan is, that it is only applicable to those few cases in which there is but little or no separation of the fragments. In the majority of transverse fractures the fragments are more or less separated, and cannot be brought into contact with each other by mere position; so that the only question for consideration is, whether the apparatus for adjustment should be applied immediately, or be deferred till all inflammation and effusion into the joint have disappeared. The strongest argument in favour of immediate adjustment is derived from the fact that the extensor muscles go on contracting for some days after the fracture; so that not only is the upper fragment still further separated from the lower, but the muscles become so shortened that the fragments cannot be brought into contact with each other after the inflammation has subsided. On the other hand, if the inflammation in the joint is severe, the usual appliances for forcibly approximating the fragments would be injurious, and some delay seems absolutely necessary. The difficulty may be overcome by keeping the limb extended on a back splint, flexing the thigh and trunk on each other so as thoroughly to relax the rectus, and then acting on the fragments by strips of plaster placed diagonally from above downwards, and crossing each other on the splint behind: or the fragments may be acted on longitudinally by the method of Dr. Sanborn, of Lowell, U.S., who fixes a long strip of sticking-plaster, two inches and a half wide, in front of the limb, from the upper portion of the thigh to the middle of the leg, leaving at the knee a free loop. A bandage being applied above and below the knee, for the purpose of securing the plaster and controlling the circulation and muscular contraction, a small stick, six or eight inches in length, is put through the loop over the knee, and the plaster twisted until the fragments of the patella are brought into apposition.* Or belts of leather may be fastened above and below the patella, and then made to approximate by longitudinal straps; or the figure-of-eight bandage with a starched bandage outside may be applied; or Eve's ring;† or Malgaigne's hooks, which consist of 'two steel plates, each an inch long and two-thirds of an inch wide, sliding upon one another, and this sliding regulated by a screw; the free extremity of each is bifurcated, and recurved into two very sharp hooks; the two hooks of the lower plate, only one-third of an inch apart, are intended to be inserted at the apex of the patella, which is lodged between them; those of the upper plate, which are to catch on the base of the bone, may be separated by a space twice as wide; and the inner one should also be longer than the outer by one-sixth to one-fifth of an inch, to make up for the obliquity of this end of the bone.' ‡ The action of this instrument is evident.

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* Coale, *Boston Med. and Surg. Journ.* vol. liv. p. 402.

The chief defect of all these contrivances is their tendency to tilt forwards the fractured edges of the patella, causing them to gape in front, and so counteracting the intention for which they were applied; with a little mechanical skill, however, this may generally be overcome, and good ligamentous, if not bony, union obtained.

The average period for which retentive apparatus should be applied is from thirty-five to forty days; if it be removed earlier, or if the patient go about too soon, or if the fragments have not been properly adjusted in the first instance, the intervening ligament will be long and weak, or union may be wanting altogether. On the contrary, a too prolonged confinement of the limb is apt to terminate in permanent stiffness. It is pretty generally admitted, that the shorter the connecting medium between the fragments, the stronger and the more useful will be the limb; but the degree of restoration of which this is capable, in cases of non-union, or of an elongated uniting ligament, is a point on which there is much difference of opinion. The writer's experience leads him to regard complete restoration as exceedingly rare, and the general insecurity under which the subjects of such accidents labour is proved by the frequency with which they fracture their other patella ; so that it may be safely affirmed, that a person who has had the misfortune to fracture one patella, becomes thenceforth prone to a repetition of the accident in his opposite limb. For these reasons it is advisable to wear a knee-cap, or some other apparatus which shall support, and, at the same time, limit the movements of the knee-joint.

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* Hamilton, *On Fractures and Dislocations*, p. 443.

† This ring was used by Dr. J. G. Fleming of Glasgow, many years ago, and its construction and mode of application are described by Dr. Gibson in the *Lancet* of July 20, 1867.

‡ Malgaigne, op. cit. p. 779.

The treatment of vertical and oblique fractures of the patella does not differ materially from that required for transverse fractures of the bone. The limb must be placed in the extended position on a Macintyre's splint, and, when the inflammation has subsided, the fragments must be brought together by firm pads, applied on each side of the bone, and fixed there by straps and the starch bandage.

Fractures of the Leg.

Causes and Pathology.—Although each of the bones of the leg may be fractured separately, it is most common to find both broken ; and the above term is usually restricted to this injury. The reason of the greater frequency of fracture of both bones than of either bone singly, is probably owing, as Mr. Lonsdale has suggested, to the fact that a force sufficient to break the tibia is generally sufficient to extend to the fibula afterwards, and so to break it ; whereas it must be a peculiar kind of force to break either the tibia or fibula singly.

Of 289 fractures of the leg admitted into the Middlesex Hospital between the years 1831 and 1837, 197 were of both bones, 51 of the fibula, and 41 of the tibia.* The extreme rareness of these fractures in infancy and childhood is a remarkable fact, especially when contrasted with the great frequency of fractures of the femur at this period, and the still greater frequency with which they themselves occur in after-life.

Of 515 cases collected by Malgaigne, but one was as young as four years, and only 12 were met with between five and fifteen years of age.

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* Lonsdale, op. cit. p. 19.

The causes of fracture of the leg are either direct, as the passage of a wheel over the limb; or indirect, as in slipping down or jumping from a height. The relative frequency of these causes in the production of this fracture has been variously estimated by different writers. Hamilton considers that four-fifths of them are caused by direct violence. The writer's experience is more in accordance with that of Malgaigne, who in 67 fractures of the leg, found 36 produced by direct violence, and 31 by indirect. Fractures from direct violence may of course be produced at any part of the bone, while those from indirect force mostly occur at the weakest part, that is, at the lower third, and they are extremely rare at the upper part of the bone.

The most frequent situation of fracture of the leg is where, from the greater weakness of the tibia, one would expect to find it, viz. in the lower third; so that of 155 fractures, from all causes, recorded by Hamilton, 93 occurred in this situation, 45 in the middle third, and only 11 in the upper third. The fibula is rarely broken at the same level as the tibia, but at a variable distance above it; most frequently, from two to three inches above it. Fractures of the leg present every variety of this injury which is met with elsewhere; but, from the superficial position of the tibia, comminuted and compound fractures are more common than in any other part of the body.

In the neighbourhood of the knee- and ankle-joints, owing to the great force which is required to break the bones, these forms of fracture prevail; it has also been observed that the direction of the fracture in these situations is prone to be vertical, and so to implicate those joints. The prevailing direction of simple fractures of the leg is oblique, with the obliquity downwards and inwards, and generally slightly forwards; less frequently it is downwards and outwards, and still more rarely downwards and backwards.

Displacements of the broken bones may take place in these as in other fractures, and from the same causes; not unfrequently, however, there is no displacement, as in some transverse fractures; and it may be stated generally, that the more nearly the fracture approaches a transverse direction, and the nearer it is situated to the upper end of the bone, the less will be the liability to displacement, and the less its amount should it occur; indeed, in transverse fractures of the tibia, although the fragments may form an angle with each other, or the lower fragment be rotated outwards or inwards, they rarely become completely disengaged. In oblique fractures, on the contrary, there is nearly always overlapping, sometimes to a considerable extent, as when the fracture is caused by a fall on the feet from a height; for here the force being more than sufficient to break the bones, continues to act, and so displaces them. Should, however, the whole of the force be expended in causing the fracture, the subsequent displacement of the fragments is usually not great, and affects almost exclusively the lower fragment, which is drawn upwards, generally behind the other, but having an inclination to the inner or outer side, according to the direction of the line of fracture which regulates it; thus, the prevailing direction of the oblique fracture being downwards, inwards, and forwards, the displacement will be upwards, outwards, and backwards. Combined with this, there is often some rotatory displacement of this fragment outwards, due probably to the weight of the foot, and its tendency to gravitate in this direction. Accordingly in 19 specimens of united fracture of the bones of the leg, examined by Mr. Shaw, 16 had the lower fragment rotated outwardly, and situated somewhat to the outer side, and behind the upper.*

Symptoms and diagnosis.—There is rarely much difficulty in detecting a fracture of the leg, the superficial position of the tibia rendering any deviation from its normal form and direction evident. When the fracture is oblique, there is shortening of the limb from two or three lines to three-quarters of an inch, and often more or less projection of the lower end of the upper fragment. In those cases, however, in which the fragments remain *in situ*, or in which there is much swelling, the nature of the injury may be overlooked; but the history of the accident, the sensations of the patient, his inability to support himself on the fractured limb, the mobility at the seat of fracture, and the crepitus on rotation, cannot fail to demonstrate its true nature. When the fracture is situated just above the ankle-joint, it is very liable to be followed by considerable displacement. If the direction of the fracture be transverse, the lower fragments with the foot will be drawn backwards, and so resemble a dislocation of the foot in that direction (as seen in Fig. 124). If the fracture be oblique laterally, the upper fragments slide down upon the lower and produce an apparent distortion of the foot, either inwards or outwards, according to the direction of the obliquity. These fractures with displacement must be distinguished from true dislocations accompanied with fracture: in the former the fracture is primary and the dislocation secondary; whereas the reverse is the case in the latter. In the displacements from fracture the articular surfaces of the tibia and astragalus maintain their normal relations to each other, and none of the ligaments of the joint are ruptured. In

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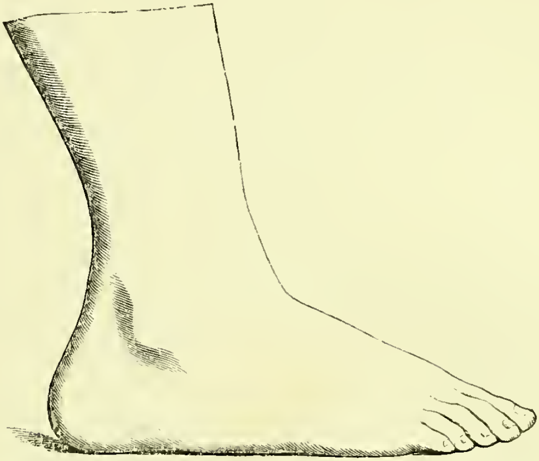
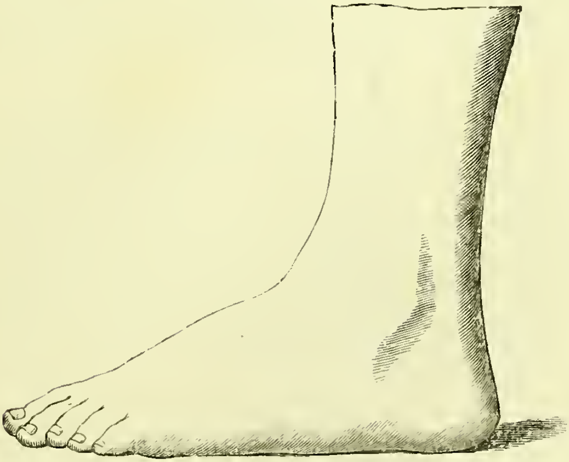
* *Path. Soc. Trans.* 1848–9, p. 125.

FIG. 124.



Displacement of foot backwards in a transverse fracture of the leg just above the ankle. (From a cast in the Museum of the Westminster Hospital.)

FIG. 125.



Cast of healthy foot from the same patient to contrast with the above.

the true dislocations, the articular surfaces of the tibia and astragalus lose their normal relations, and some of the ligaments of the joint are ruptured. Then, as to the deformity which results from these accidents: in the true dislocations of the foot backwards, the malleoli are nearer the ground, whereas in the displacement from fracture they maintain their proper relations to the foot. The motions of the ankle-joint are lost in the former, they are preserved in the latter. In the lateral displacements likewise, though the foot may be situated outwards or inwards relatively to the leg-bones, its plantar surface rests flat on the ground, and not on its outer or inner borders, as in dislocation.

An interesting case of separation of the lower epiphysis of the tibia has been published by Professor Quain in the *British Medical Journal*, August 31, 1867. The subject of the accident was a healthy-looking lad, seventeen years of age, who, on dragging a piece of iron over a heap of earth, slipped and fell, his left foot being doubled under him. The lower end of the tibia projected forwards, and below the prominence there was a depression between it and the foot. The projection of the bone was an inch and a half higher than the lower margin of the fibula, and three-quarters of an inch above the lower edge of the malleolar process of the tibia. The space between the prominent tibia and the end of the great toe on the injured side, measured three-quarters of an inch less than in the other foot; the ankle-joint was uninjured; and Mr. Quain remarks that this accident differed from a fracture of the bones above the ankle-joint, in the absence of a sharp edge of a broken bone, and the smooth and rugous feel of the displacement, as well as in the absence of swelling occasioned by the effusion of blood. The bone was replaced without difficulty, and a starched bandage applied.*

Treatment.—All fractures of the leg are quickly followed by more or less swelling, and there are few simple fractures which it is not advisable to put up as soon after the accident as possible. If this be deferred, the swelling increases, the sufferings of the patient are prolonged, and the cure is rendered more tedious. The mode of putting up these fractures may be varied according to the nature of the case. In some, the fragments are in such good apposition, and there is so little tendency to displacement, that it is a needless cruelty to keep the patient in bed for five or six weeks. A starch or glue bandage may therefore be put on at once, and the patient allowed to get about on crutches a few days after the accident. In other cases, the local symptoms and the general condition of the patient may be such as not to admit of this kind of treatment. Thus if there should be much displacement or overlapping of the fragments, it will sometimes be found impossible to get them into place without first bending the thigh, leg, and foot at right angles with each other, and then making extension and counter-extension from the knee and ankle; and should there be a tendency to displacement of the fragments when the leg is straightened, it is advisable to keep the patient on his side with the limb supported between Sharp's splints, and well flexed so as to relax the most powerful muscles. This is also the easiest and most natural position for the patient to lie in, and it admits of a ready examination of the limb without disturbing it, by simply unbuckling the straps and removing the upper splint. To render this method of treating fractures of the leg perfect, the splint should have a second curve, at the upper part of the leg-piece, at right angles with it, and in an opposite direction to the lower, so as to embrace the knee-joint and lower third of the thigh. With such splints, firmly securing the joints above and below the fracture, no displacement or movement of the fragments on each other could possibly happen. Indeed, Hamilton is of opinion that this, which is Pott's method slightly modified, is the best, and is applicable to nine-tenths of all simple fractures, and to some compound. In these it is necessary for one of the splints to be interrupted, and an ingenious modification of the ordinary interrupted splint has been invented by Dr. Skipton; the essential feature of which is, that it consists of several pieces, any one or more of which can be removed, so that no matter in what part of the leg the wound may be, the same splint will serve. When the fracture admits of being put up in the straight position, it is preferable in my opinion to do so, and for this, almost any of the splints or apparatus ordinarily in use will answer the purpose. The points to be attended to in their application, are—1, to secure the knee and ankle-joints so that no axial rotation of the fragments shall take place; 2, to see that the foot is at right angles, or nearly so, with the leg; 3, that the ball of the great toe is in a line with the inner border of the patella; and 4, that there is no shortening of the front part of the foot from the sinking back of the heel. In the last edition of this work I spoke of Neville's splint as a very efficient and simple kind of apparatus in use in St. Bartholomew's Hospital, and in the *Lancet* of February 1868, will be found an excellent practical lecture by

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* Preparations showing separation of the epiphyses of the lower end of the tibia and fibula, have been exhibited by Mr. Holmes, and are published in the *Path. Soc. Trans.* vol. xiii. p. 187. See also *Diseases of Children*, 2nd edit. p. 236; *New Sydenham Society's Biennial Retrospect* for 1867–8, p. 258.

Mr. Paget, in which the details of its application are fully described.

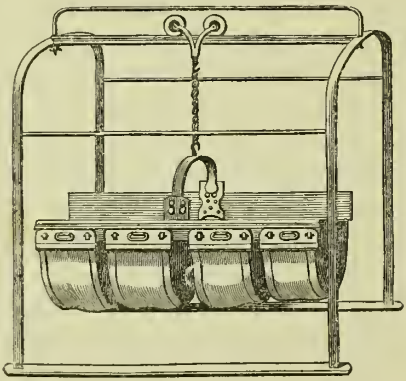
It consists of a back and two side splints. The back splint is a long and nearly flat piece of iron; bent at a right angle for the foot, and having two short cross-bars projecting from its side and looped to receive slings; its breadth is three and a half inches at the broadest part, and two and a half at its narrowest. It has an opening for the heel, and is slightly curved from above downwards, to correspond with the natural curves of the limb, and should be long enough to extend nearly half way up the thigh. The side-splints are of wood, and flat, and should be long enough for the ends to project a little beyond the foot-piece, and to reach to some three or four inches above the patella, and broad enough to enable the straps that are put round them completely to encompass them without touching the leg. These splints, well padded, are secured in their place without the use of the ordinary bandage; the foot, which should touch the foot-piece by the three balls of the sole, is held there by gutta-percha moulded to the dorsum, separated from the skin by a layer of flannel, and coming over the edges of the foot-piece, is fastened there with tapes or string. The side-splints are held together by a similar contrivance of gutta-percha moulded to the knee, and secured by straps and buckles. They are further held in place by two transverse bands, which buckle across their lower end beyond the foot-piece. The limb is then slung in a simple cradle, and at the end of three or four weeks, if the fracture be simple and uncomplicated, it is put up in a plaster of Paris bandage. The only other apparatus that need be specially named, is that of Hester, of Oxford, which well fulfils all the indications above pointed out.

The treatment of compound fractures must depend entirely upon the amount of injury. The slightest form is that which occurs subsequent to the accident that caused the fracture, as when the upper fragment is thrust through the integuments on moving the patient, or when the skin ulcerates over a projecting fragment. For these nothing more is necessary than to restore the bone to position, and seal the wound hermetically with collodion and oiled silk, or with Lister's dressing of carbolic acid, described below. A more severe form is that which takes place at the moment of the accident, as on falls on the feet from a height, when the weight of the body forces the upper fragment through the skin. In these it is sometimes difficult, and even impossible, to reduce the fracture without enlarging the wound, or even sawing off a portion of the projecting bone. But when we have succeeded by these means in placing the fragments in apposition, the edges of the wound may be brought together and sealed hermetically, as above directed. The worst forms of compound fracture are those produced by direct violence, as the passage of a heavy wagon or railway-car over the limb. And in these there is usually so much injury and destruction of the soft parts as well as of the bones, that immediate amputation is the only proper course to pursue. In other cases, although there may be extensive comminution of the bones, and laceration and bruising of the soft parts, as in kicks from a horse, an attempt should nearly always be made to save the limb.

Perhaps the best guide to the treatment of bad compound fractures is to be found in the amount and importance of the soft parts left uninjured by the accident. If the temperature and sensation of the foot are perfect, we may be sure that the principal nerves and blood-vessels of the limb are uninjured, and that they will be sufficient for the repair of the injury; whereas under contrary conditions, its salvation can hardly be looked for. There is a variety of simple fracture (using that term to signify a fracture without breach of the integuments) quite as bad as the worst forms of the compound, and equally with them calling for immediate amputation. It is that in which all the structures, except the skin, are completely crushed and pulpified. When the attempt to save the limb is determined on, the wound must be cleansed, all foreign bodies or loose fragments of bone removed, the bones brought into the best position, and such an apparatus selected as will admit of the ready dressing of the wound without disturbing the fracture. One of the best for this purpose, is Macintyre's splint, as improved by Liston. Before any dressings are permanently applied, care must be taken that all bleeding has ceased, and until then, the wound should be left open. I have seen compresses put on to stop venous hæmorrhage divert the blood from the exterior to the interior of the limb, and so cause extensive extravasation beneath the skin, and among the muscles. The subsequent treatment may then be conducted on general principles, as laid down in the essays on wounds and fractures. This section would, however, be incomplete without alluding to the antiseptic principles of treatment introduced by Professor Lister, and strongly advocated by Professor Syme. The theory of the practice may be enunciated in the following propositions. 1st. All the local inflammatory mischief and general febrile disturbance which follow severe injuries, are due to the irritating and poisoning influence of decomposing blood or sloughs. 2nd. This decomposition is owing to the presence of minute organisms suspended in the air. 3rd. To prevent this decomposition, with its attendant evils, it is necessary to apply as a dressing to wounds, some material capable of destroying the life of the floating particles. 4th. Carbolic acid, from its destructive influence on low forms of life, is the most powerful antiseptic with which we are acquainted, and hence the most proper dressing for wounds.

The preparations employed by Mr. Lister,* are the carbolic oil, carbolic lotion, and carbolic paste. The composition of the first is, carbolic acid one part, boiled linseed oil five parts; that of the second, carbolic acid one part, water twenty parts; and that of the third, carbolic oil, with whitening in the proportions requisite to form a soft putty. In the treatment of bad compound fractures of the leg, Mr. Lister first swabs all the recesses of the wound with a piece of rag dipped in strong carbolic acid; rag dipped in carbolic oil is then placed over the wound, and maintained there permanently; while the paste is laid on outside this, and overlaps the sound skin for a considerable distance. 'The putty should be in a layer of a quarter of an inch thick, and may be advantageously applied rolled up between two pieces of thin calico.' To prevent evaporation of the acid, the paste should be covered with tinfoil strengthened with adhesive plaster. As long as any discharge continues, the paste should be changed daily, but when it has ceased, it is discontinued. The original oiled rag is left adhering to the skin, till healing by scabbing is supposed to be complete. At a later period of the treatment, it is sometimes desirable to release the patient from the position which was adopted in the first instance, and to swing the leg in a cradle, of which one of the best is that of Mr. James Salter.† This differs from all others in the greater freedom of movement it allows to the patient without risking the disturbance of the fracture.

Fig. 126.



Salter's Swing.

Fractures of the fibula.—Any part of this bone may be broken by direct violence, and the fracture be unaccompanied by displacement or other injury; but most frequently the bone yields to indirect force, at a point from two to four inches above the extremity of the malleolus, and this is accompanied by a partial dislocation of the foot.

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* See *British Medical Journal*, Sept. 21, 1867; also Jan. 4, 1868.

† 'On a New Swinging-Apparatus for the Treatment of Fractures of the Leg,' by S. James A. Salter, M.B., &c., in *Provincial Med. and Surg. Journal*, 1850, p. 564.

The accident is caused either by a sudden twist of the foot, outwards or inwards, or by its becoming fixed in a cleft, and the body, falling to one or the other side, as in the well-known case of Sir Astley Cooper, who fractured his right fibula by falling on his right side while his foot was entangled between two pieces of ice.

As to the relative frequency of the causes which produce the fracture—of 200 cases which came under the observation of Dupuytren, 20 were the result of direct violence, 60 were produced by forcible eversion of the foot, and 120 by forcible inversion. The greater frequency of this injury from indirect violence than from direct is generally admitted; but in the experience of English surgeons, eversion of the foot is a more frequent cause of this fracture than inversion.

Hamilton, in a record of 32 fractures of the fibula, was able to ascertain the cause satisfactorily in 18. Of these, '3 were the result of falls directly upon the bottom of the foot, 4 of a slip of the foot in walking on level ground, or on ground only slightly irregular; and 12 (query 11) of direct blows. In all of the fractures which have been produced by falls on the bottom of the foot, and in all except one produced by a slip of the foot, the accident was accompanied with a dislocation of the ankle, the foot being turned outwards.'* In 7 also of the 11 (?) produced by direct blows, the tibia was thrown more or less inwards and the foot outwards. These 18 cases in which the cause of the fracture is said to have been ascertained, are obviously too few to invalidate the general belief in the greater frequency of indirect than direct fractures of the fibula; neither is it credible that a fall flat on the foot without a subsequent twist of it, or what amounts to the same thing, an inclination of the body to one side, could fracture this bone. To produce such a result, there must be a change in the direction of the line of transmission of the weight of the body from the tibia to the fibula. In the fracture from eversion, the internal lateral ligament is frequently torn through, and even the inner malleolus fractured, but in the fracture from eversion, the external lateral ligament remains entire, and probably contributes to the fracture, the bone yielding to the pressure of the astragalus against the external malleolus.

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* Hamilton, op. cit. p. 453.

Displacement of the foot does not necessarily follow a fracture of the lower third of the bone, even when caused by indirect violence; and Malgaigne affirms, with much positiveness, that in the majority of fractures by adduction there is no displacement whatever, and that when it occurs, it is secondary, and owing to the patient's attempt to walk; when the foot becomes turned outwards, as in the fracture from abduction. Even when produced by the latter cause, he affirms there may be no appreciable displacement. Hamilton, on the contrary, as before quoted, found displacement in all but one of his indirect fractures, and in all but three of the direct; while Dupuytren asserts that nine-tenths of his fractures were attended with displacement. It is probable that Dupuytren has as much exaggerated the frequency of the subsequent dislocations as Malgaigne has underrated their frequency. With reference to the obliquity and the position of the fragments, it may be stated, generally, that fractures from indirect violence are usually more or less oblique, and those from direct, transverse; and that when displacement of the foot occurs, as a consequence of the fracture, the broken ends of the bone will project inwards towards or even against the tibia.

Symptoms.—A fracture of the fibula, unless attended with displacement of the foot, cannot be recognised by any external sign, for the fragments are kept in apposition by the tibia, and there is, consequently, no deformity; while ecchymosis, if present, may exist independent of fracture. The best means of detecting the fracture is by grasping the leg with both hands, and with the thumbs making alternate pressure on the bone immediately above and below the suspected fracture, when, if it exist, motion and crepitus will at once be felt; or, if the fracture be situated just above the malleolus, the lower fragment may be acted on by forcibly inverting and everting the foot, while the thumb of the other hand is placed over the fracture; the characteristic signs will thus be elicited.

Treatment.—For a simple fracture of the fibula in its upper two thirds no treatment besides rest is necessary; but in the lower third of the bone the application of some apparatus is advisable, even should the fragments not be displaced. Nothing is better for this purpose than the starch bandage, strengthened by pasteboard splints, on the inner and outer sides of the foot and ankle, care being taken that no displacement occurs during their application, or while the apparatus is drying. In those cases of fracture accompanied with marked displacement of the foot, and therefore rupture of the internal lateral ligament (Pott's fracture),* Pott's method may be adopted. This consists in placing the patient on his injured side, with the knee bent and the foot somewhat inverted, so as to insure the broken ends of the bone being in contact with each other, and not with the tibia. A Sharp's splint, well padded, and having the pad for the foot-piece thicker than that for the leg, so as to raise a little the outer border of the foot, should next be applied on the outer side of the limb, and, for greater security, an inner splint without a foot-piece may also be placed on the inside of the limb. Dupuytren considered that Pott's method was insufficient to maintain the reduction, and directed the foot to be brought into such a state of adduction as that its inner edge should become superior, its outer edge inferior, and its sole directed inwards. For this purpose he employed a wedge-shaped cushion, the thick end of which was downwards and applied upon the inner malleolus; over this a splint was laid, which reached from the knee to three or four inches beyond the edge of the foot; the leg being then secured to the splint, the foot was next drawn inwards, and firmly fixed to the projecting end of the latter. The principle of this method is to make the foot act as a lever on the lower fragment of the fibula, so as to draw it outwards from the tibia, while at the same time the lateral pressure fixes the astragalus firmly against the inner malleolus.

The period for which any apparatus should be kept on will depend on the situation of the fracture, and the injury done to the ankle-joint. In fractures of the upper part of the bone, it has been already stated that no application is necessary; but in the lower part, even should there be no displacement, splints should be kept on for three or four weeks; and in case of a dislocation of the foot, for six weeks or two months. In all fractures of the fibula in its lower third, great caution should be observed in using the limb after the removal of the apparatus, and it may be well to support the joint for some time by a laced boot, strengthened on the inner side; the sole should also be made somewhat thicker on its inner than its outer edge.

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* See p. 919.

Fractures of the tibia.—A direct blow on the tibia, as a kick, will sometimes break this bone without the fibula, and the fracture may be situated at any part, or take any direction; it is, however, more commonly met with in the upper than the lower half of the bone, and is more frequently transverse in direction than when accompanied with fracture of the fibula; this circumstance, together with the integrity of the latter bone, renders displacement of the fractured ends almost impossible, and the diagnosis of the injury is thus oftentimes obscure. 'In some kind of fractures near to the ankle-joint, when the injury is caused by a fall, and not by a direct blow, there may be displacement, although the fibula remain entire; for the weight of the body will continue the force onwards after the tibia is broken, and so produce a distortion in the position of the foot and ankle-joint, according to the direction in which the force is applied. Thus, in a fracture of the lower end of the tibia, about an inch or an inch and a half above the ankle, that portion of the bone connected with the astragalus will move in whatever direction the foot is forced, and so may be twisted upon the shaft of the bone, or pushed backwards or forwards to a sufficient extent to produce a marked distortion.'* When, however, from the absence of all displacement of the fragments, the existence of fracture is doubtful, it may be suspected if pain constantly persists in one part of the bone, if this pain be increased by pressure, and, above all, by bearing any weight on the limb; but to convert suspicion into certainty, the limb should be firmly grasped above and below the suspected fracture, and attempts made to bend it; by its yielding to, or resisting the force applied, we ascertain whether it is broken or otherwise.

Treatment.—Of all the fractures of the lower extremity, this is perhaps the best adapted for the immovable apparatus, the application of which, *mutatis mutandis*, may be made in the same way as directed for fractures of the femur.

Mr. J. Gillingham of Chard, claims to have invented an instrument with which he has had great success in procuring the union of ununited fractures of the leg. In the case of a 'fat heavy man' the bones remained ununited two years and a half after the accident, yet in nine months after wearing this instrument, the union was so firm that he could walk several miles, and was able to follow his ordinary occupation as a labourer. The instrument can be equally adapted to ununited fractures of the femur. It consists of, first, a collar which is moulded to the leg just below the knee, and on each side of which is a stud; secondly, of a boot with a socket at the heel; and, thirdly, of two steels, with ankle-joints bifid at the top to catch the studs on the collar, and capable of elongation or shortening, as seen in the engraving. Thus the weight of the body is taken off the leg-bones, and transmitted down the two side-steels. Mr. Gillingham assures me that patients are able to walk without crutch or stick, mmediately the instrument is put on.

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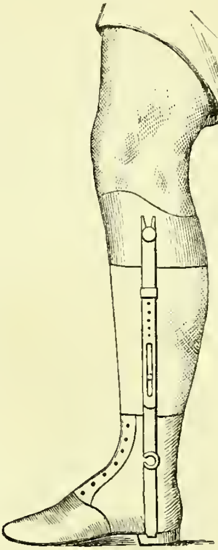
* Lonsdale, *On Fractures*, p. 110.

Fig. 127.



Mr. Gillingham's instrument for ununited fracture of the leg.

Fractures of the Foot.

These are most frequently caused by heavy bodies falling upon it or crossing over it, and so crushing it: hence the soft parts also are not unfrequently lacerated, or contused to such an extent as to require the removal of a part, or the whole, of the member ; if, on the contrary, the soft parts are not much injured, rest and support, together with evaporating lotions, constitute the only treatment necessary.

The only bones of the tarsus the fractures of which require special notice are the astragalus and os calcis. The fracture of the former, according to Malgaigne, is always caused by a fall from a height, and it is often the only tarsal bone which is broken, while in a general crushing of the tarsal bones, it nearly always escapes injury. The direction of the fracture is various, though most frequently it is through the neck of the bone, and, unless compound, cannot usually be detected ; in the latter form of injury, the portion displaced should be returned, or, if completely isolated, removed.

The os calcis may be broken either by crushing, falling from a height on the heel, or by muscular action. Malgaigne considers the latter mode of fracture problematical; he could find only eight cases recorded, and most of them so loosely that they fall far short of proof. In two cases the fracture was said to have been the result of a false step ; in one it was caused by the upsetting of a wagon; in five by falling from a height on the feet. The fracture is always situated behind the astragalus, and, we may presume, ought to be vertical in direction; but in the published accounts of this fracture this point is left in uncertainty. The extent to which the detached fragment is drawn up by the gastrocnemius and soleus has been found to vary from almost nothing to five inches; a difference which is probably owing to the part at which the fracture has taken place, and whether the posterior fragment is completely isolated from the rest of the bone, or is partially connected with it by the fibrous structures in the sole. The nature of the injury is easily detected by examination; in addition to the pain, swelling, and deformity, the detached portion can be felt, and its relative distance from the heel will be lessened or increased by extension and flexion of the foot. The treatment consists in subduing the inflammation and keeping the foot extended and the leg flexed, by any of the contrivances made use of in rupture of the tendo-achillis. In fractures by crushing, the symptoms are more severe, the pain, swelling, and ecchymosis greater, and the crepitation more obscure; the two most characteristic signs are, increased width of the heel, and lowering of the arch of the foot. This fracture has been mistaken for a sprain, and for a fracture of the fibula without displacement, from either of which it may be distinguished by the above-mentioned symptoms and a careful manual examination. Consolidation takes place slowly, and it is often several months before the functions of the foot and ankle are restored.

The best method of treatment consists in placing the limb on its outer side, on a Sharp's splint, till all the acute symptoms have subsided, when some of the forms of the immovable apparatus may be substituted, and the patient allowed to go about on crutches. The apparatus should be worn for two months before attempting to use the foot. Fractures of the metatarsal bones and phalanges are always the result of direct violence, and, if simple, require no treatment but rest, and the ordinary remedies to subdue inflammation. If compound, the treatment must be regulated by the number of bones fractured, their degree of comminution or displacement, and the condition of the soft parts; if the latter are not bruised beyond recovery, and if the former can be replaced, and the constitution of the patient is good, an attempt should be made to save the foot. Under opposite circumstances, the injured parts should be removed, care being taken to leave as much of the sound portions as shall insure a useful stump.

Dislocations.

Dislocations of the Hip.

The head of the thigh-bone, though lodged in a deep cavity to which it is accurately adapted, and in which it is retained by atmospheric pressure, and by strong ligaments and muscles, is yet more frequently displaced than these physical and anatomical dispositions would seem to admit of. Indeed, if reliance is to be placed on the statistics of this accident collected by M. Malgaigne at the Hôtel Dieu, there is no joint of the lower extremity in which dislocation occurs so frequently as in the hip: next to the shoulder, it is the most liable to this accident of any joint in the body, as seen in the following table.*

In 491 cases of dislocation, there were—of the

Shoulder	321	Thumb	17	Knee	6
Hip	34	Wrist	13	Radius	4
Clavicle	33	Fingers	7	Patella	2
Elbow	26	Jaw	7	Spine	1
Foot	20				

This great proneness to displacement of the shoulder and hip-joints is doubtless owing in part to their extensive range of motion, and in part to the powerful leverage which may be exerted on them by a force applied to the distal extremities of the respective limbs, or of the humerus and femur. Dislocations of the hip are nearly always accidental, and result from the application of great force; hence, we should expect to meet with them most frequently in the male sex, and at the most active period of life; this is fully borne out by the accompanying table from Malgaigne. In fifty-one cases of dislocation of the hip, forty-two were males, and nine females; and the following were the ages of the sufferers:

At 3 years of age	1	From 45 to 60	10
From 15 to 20	8	„ 60 to 85	5†
„ 20 to 45	27		

In the 56 cases of this accident collected by Sir A. Cooper, the age of the patient is not stated in 11; but in the remaining 45, I find 7 were under 20 years of age, 7 were 50 and upwards, and 31 between 20 and 50.* The earliest recorded age at which a dislocation of the hip has occurred is six months: it was into the obturator foramen, and was easily reduced by manipulation.† Although dislocations of the hip cannot usually happen without the application of great force, individuals have been met with who possessed the power of voluntarily dislocating their hip, and again reducing it, as related by Sir A. Cooper,‡ Stanley § and Brodie.||

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* *Traité des Fractures et des Luxations*, 1855, tome ii. p. 8.

† Ibid. p. 805.

Dislocations of the hip sometimes take place spontaneously, in consequence of paralysis of the muscles external to the joint, or from disease of the joint itself; they are also occasionally met with as congenital affections, due to causes acting in utero, or to violence inflicted during birth. In the present essay we have to treat of those dislocations of the hip which result from violence; and they occur most frequently in the following directions:—

1st. The head of the bone is thrown upwards, and more or less backwards, upon the dorsum ilii.

2nd. Backwards, and slightly upwards, or into the ischiatic notch.

3rd. Downwards and inwards, or into the obturator foramen.

4th. Upwards and inwards, or upon the body of the pubes.

The proportion in which these dislocations are met with, are, according to Sir A. Cooper, the following: in 20 cases, there will be 12 on the dorsum ilii, 5 into the ischiatic notch, 2 into the obturator foramen, and 1 on the pubes. In 104 cases collected by Hamilton (excluding the anomalous dislocations), 55 were upon the dorsum ilii, 28 into the ischiatic notch, 13 into the obturator foramen, and 8 upon the pubes.

In the experience of Malgaigne, Chelius and Fergusson, the dislocation into the obturator foramen is the most rare. Besides the four ordinary dislocations of the hip, some anomalous ones have been described, of which mention will be made presently.

Pathology.—The injuries which are common to all the above varieties of dislocation, are laceration, and sometimes complete

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* *On Dislocations and Fractures of the Joints*, 5th edition, edited by Bransby B. Cooper.

† This unique case is recorded by Mr. Powdrell in the *Lancet* of 1868, vol. i. p. 617.

‡ Op. cit. Case 2.

§ Vide Stanley, *Med.-Chir. Transactions*, vol. xxiv.

|| Brodie, *On the Joints.*

detachment of the capsular and round ligaments from the femur and the acetabulum, and a stretching or tearing through of one or more of the muscles which surround the joint.

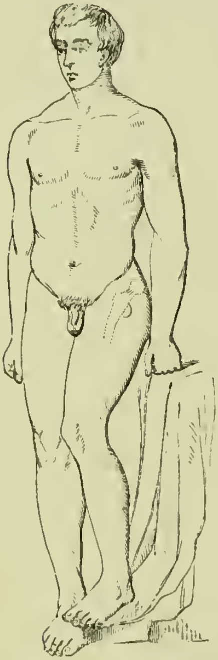
1. *Dislocation upwards and backwards, or upon the dorsum ilii.*—In this dislocation the head of the femur is thrown upwards, and more or less backwards, and will occupy different positions in different cases, as already observed. In one case it has been found lying partly on the bone, partly on the gluteus medius, and partly on the pyriformis muscles; in another, between the gluteus maximus and the posterior border of the gluteus medius; and in another, underneath the inferior border of the gluteus medius, by which it was fixed in its unnatural position. The small external rotator muscles of the hip are either put upon the stretch, or some or all of them may be torn across. With respect to the height to which the head of the femur may ascend in these iliac dislocations, Malgaigne found, in 11 preparations of this accident which he examined, that in 5 it did not ascend higher than a line drawn from the anterior superior spinous process of the ilium to the highest point of the ischiatic notch; in 2, it ascended half a centimetre (about one-sixth of an inch) higher; in 2, 1 centimetre; in 1, 1 centimetre and a half; and in 1, 2 centimetres. The limits of the displacement below were never lower than the point of junction of the ilium with the ischium; but the limits posteriorly were somewhat greater.

Symptoms.—The limb is from an inch and a half to two inches and a half shorter than its fellow; it is rotated inwards, adducted and slightly flexed; so that when the patient is standing, the knee of the affected side is somewhat in front of, and above the other, and the toes rest on the tarsus of the opposite foot; the great trochanter is directed forwards, and lies nearer to the anterior superior spinous process of the ilium than natural, while the head of the bone is directed backwards, and, in thin persons, may be felt lying upon the dorsum ilii. The only movement of which the limb is capable, unless great force be used, is a slight one in the sense of flexion, adduction and rotation inwards; its elongation, extension and abduction cannot be accomplished, and the attempt is productive of great pain.

2. *Dislocation backwards and slightly upwards, or into the ischiatic notch.*—In this dislocation, which is merely a variety of the former, the head of the bone is thrown slightly up-

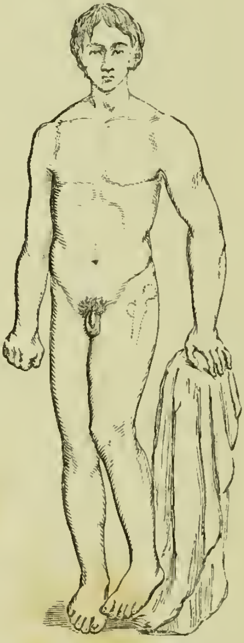
wards, as well as backwards. Syme found the gluteus maximus nearly torn across, and the head of the bone embedded in it was lying in the great ischiatic notch, upon the gemelli and the sacro-sciatic nerve. The gluteus minimus, the pyriformis, and the gemellus superior were lacerated. The symptoms very closely resemble those of the dislocation upwards, but are less marked. Thus the shortening of the limb rarely exceeds half an inch; its adduction, inversion, and flexion are less; so that in standing the knee projects but slightly beyond the other, and the point of the great toe rests on the ball of the great toe of the opposite foot, instead of on the tarsus. The trochanter is somewhat behind and above its normal position, but remains nearly at right angles with the ilium, while the head of the bone is so buried in the ischiatic notch that it cannot be felt. The limb is fixed, and all voluntary movements are abolished.

Fig. 128.



Dislocation of the hip on the dorsum ilii. (From Sir A. Cooper.)

Fig. 129.



Dislocation of the hip into the sciatic notch. (From Sir A. Cooper.)

Causes.—These dislocations, according to Sir A. Cooper, are most commonly brought about by a fall whilst carrying a heavy load on the shoulders, or by a heavy weight, such as a mass of earth falling on the back whilst the body is bent forwards in a stooping posture.

Diagnosis.—There is not much likelihood of either of these dislocations being mistaken for any other injury, though certain fractures in the neighbourhood of the hip do occasionally resemble them. Among these may be enumerated fractures of the neck of the femur, with inward rotation of the limb, especially if the fracture be complicated with one of the great trochanter; a portion of the latter may then be drawn by the action of the muscles towards the great sciatic notch, or upon the dorsum of the ilium, and so resemble the head of the bone in those situations, as, indeed, happened in the following case related by Smith, and which was at first mistaken for a dislocation.

The patient was an old man, eighty years of age, who died on the fourteenth day after the accident. During life the limb was shortened two inches, the foot inverted, and the entire limb in a state of adduction; the trochanter major could be felt upon the dorsum of the ilium, a little above the situation of the sciatic notch. After death, there was found a transverse serrated fracture of the neck of the femur external to the capsule; at the line of junction of the cervix with the shaft of the bone a second fracture detached the trochanter major, which was drawn upwards and backwards, carrying with it the insertions of the pyriformis, gemelli, and obturator muscles.*

Another fracture which somewhat resembles these dislocations is that of the acetabulum, with shortening and inversion of the limb; but in all these fractures the shortening can be overcome by traction, and recurs when this is remitted. There is also crepitus.†

Treatment.—In nearly all dislocations of the hip it will be advisable to bring the patient under the influence of chloroform before making any attempts at reduction, and as soon as this is effected, a long splint should be applied to the outside of the limb and trunk, and not removed for two or three weeks. There are two methods of reducing these, and the other dislocations of the hip—one by means of traction, and the other by manipulation. In describing the former we shall follow the rules laid down by Sir A. Cooper. In the dislocation upon the dorsum ilii, attempts may first be made to reduce the bone by placing the foot in the perinæum of the side affected, and using it as a counter-extending force, while with the hands the thigh is grasped just above the knee; or, what is better, let a jack-towel be fixed to it by means of the clove-hitch, while the other end of the towel is carried round the shoulders of the surgeon; the latter should then incline backwards at the same time that his foot is making increasing pressure in the perinæum; this, with slight rotation of the limb, has proved successful in several dislocations reported by the late Mr. Morgan and Mr. Cock, in *Guy's Hospital Reports*.* Should these efforts not prove successful, a sheet must be passed between the dislocated thigh and the perinæum, and its ends fastened to a staple firmly fixed to the floor or wall behind the patient, and somewhat below him, so as to be in a line with the axis of the displaced limb; or a strong well-padded leather girth, with an opening in it sufficiently large to admit the injured extremity, and to press on the perinæum on one side and the crest of the ilium on the other, may be substituted for the sheet. The trunk being thus securely fixed, a padded leather belt, with straps and rings attached, is to be tightly buckled to the thigh above the knee, or a jack-towel may be fastened to the limb, previously protected by a wet bandage, by means of the clove-hitch. The knee being now slightly bent and brought across the opposite thigh, a little above the knee, one end of a multiplying

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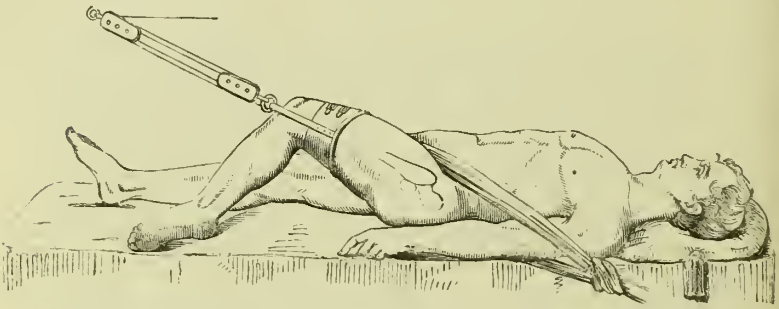
* Op. cit. Case 29, p. 85. See also similar cases by Stanley in vol. xiii. of the *Med.-Chir. Trans.* p. 504.

† For an interesting case by Mr. Birkett, in which a dislocation of the head of the femur was complicated with its fracture, the reader is referred to vol. lii. of the *Med.-Chir. Trans.*

Fig. 130.



Reduction of dislocation of the hip on the dorsum ilii. (After Sir A. Cooper.)

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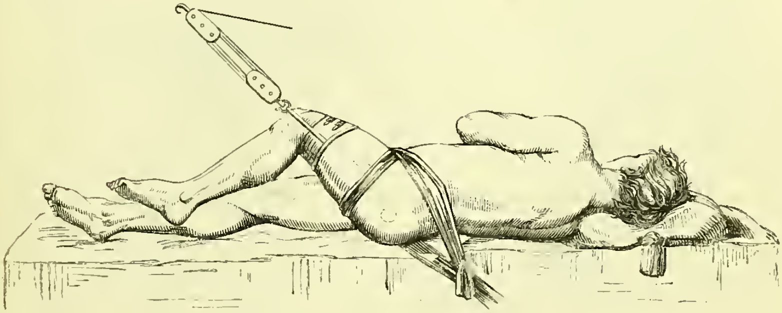
* Vol. i. p. 79.

pulley should be fixed to the rings of the leather belt or towel, and the other end to a staple fixed in the wall in front of the patient. The extending and counter-extending forces being thus adjusted in the axis of the displaced limb, traction should be slowly made with the pulley till the head of the bone has approached the acetabulum, when on the surgeon gently rotating the limb inwards, the bone usually slips into its place. If difficulty occur in raising the bone over the acetabulum, a towel is to be placed under the thigh, as near the joint as possible, so that the bone may thus be lifted over the edge of the socket. When this is accomplished, the movements of the joint will be found to be perfectly restored: and this is the best, and indeed the only test of reduction which is necessary.

The reduction of the dislocation into the ischiatic notch may be effected in nearly the same way as the dislocation on the dorsum ilii, the chief points of difference being, that the patient should be placed on his sound side instead of on his back; that the direction of the extension should be across the middle of the sound thigh instead of immediately above the knee; and lastly that the head of the bone should be assisted over the edge of the acetabulum, by means of a round towel placed under the upper part of the thigh and over the shoulders of an assistant, who, at the same time resting both his hands on the patient's pelvis, gradually raises his body, and so lifts the bone into its socket. Notwithstanding the reduction of this dislocation is pronounced by Sir A. Cooper to be in general extremely difficult, the cases which he has given in illustration scarcely bear out his assertion. This is one of the forms of dislocation of the hip in

FIG. 131.

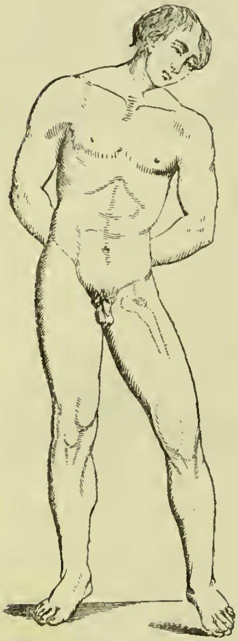


Reduction of dislocation of the hip into the sciatic notch. (After Sir A. Cooper.)

which the flexion method of reduction has been practised with great success, after the ordinary means had failed. Thus Mr. Wormald succeeded six weeks after the accident, and when pulleys had been used in vain.*

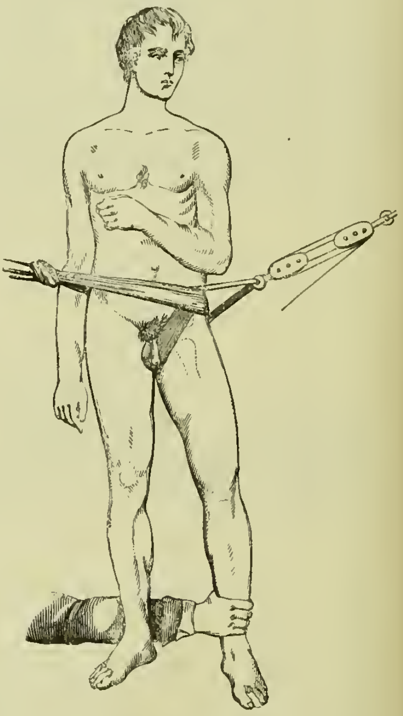
3. *Dislocation downwards and inwards, or into the obturator foramen.*—In the dislocation downwards, the head of the femur is thrown into the obturator foramen, and lies upon the obturator externus muscle; the pectineus and adductor brevis have been found torn, and the psoas and iliacus muscles, together with the glutei and the pyriformis, put on the stretch or partially lacerated.

Fig. 132.



Dislocation of the hip into the obturator foramen. (After Sir A. Cooper.)

Fig. 133.



Reduction of dislocation of the hip into the obturator foramen. (After Sir A. Cooper.)

Symptoms.—The limb is lengthened to the extent of about two inches; it is abducted and advanced in front of the other; the foot is pointed forwards, and neither inwards nor outwards; the trochanter major is less prominent than natural; and there is a slight concavity at the upper and front part of the thigh, behind which the head of the bone can be felt on making deep pressure; the body is bent forwards and somewhat to the injured side by the psoas muscle. The limb cannot be adducted or extended without some force, and this movement causes pain and numbness.

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* *Medical Times and Gazette,* Aug. 16, 1856.

Causes.—Any accident by which the thighs become suddenly and violently separated from each other, is sufficient to produce this dislocation; hence it has happened from heavy weights, as a mass of earth, falling on the back and forcing the limbs apart. Pirrie saw it caused by a person jumping out of bed in great haste, whose right foot was entangled by the blankets in bed while the left foot reached the floor.* It has also been known to occur from the sudden movement of a carriage which a person was in the act of mounting, having one foot on the ground, and the other on the step of the vehicle.

Treatment.—The reduction of this dislocation may be accomplished in the following manner: If the dislocation be recent, the patient should be laid on his back, and the pelvis fixed by a girth, which is made completely to surround both ilia, while its ends are fixed to a staple placed on the opposite side to the injured limb. Another girth is to be placed between the pudendum and the upper part of the luxated thigh, and its ends carried underneath the other, so that the two shall interlock. A pulley being now attached to these ends, extension must be slowly made, in a direction obliquely upwards and outwards, until the head of the bone begins to move from its abnormal position. The surgeon must then grasp the ankle of the dislocated limb and draw it towards and behind its fellow, when the bone usually slips into its place. Care must be taken not to raise the limb too much while adducting it, or the head of the bone may be thrown into the ischiatic notch.

4. *Dislocation upwards and inwards, or on the pubes.*—Notwithstanding this dislocation is usually designated as the dislocation on the pubes, the head of the femur does not rest so much on that bone as on the ilium; hence the term ilio-pubic, which is applied to it by Malgaigne, is the more correct designation. In an old dislocation of this nature, dissected by Sir A. Cooper and figured in his work, the head and neck of

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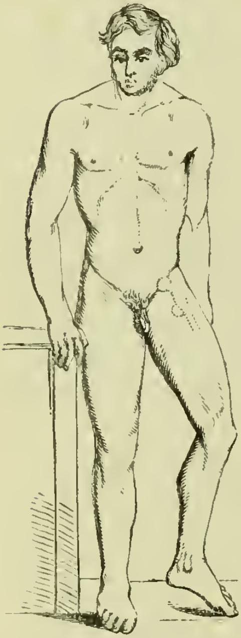
* Pirrie, *Principles and Practice of Surgery*, p. 320.

the bone occupied a position beneath the psoas and iliacus muscles, and the anterior crural nerve, and external to the femoral artery and vein. Upon the pubes (qy. ilium?) a new acetabulum was formed for the neck of the thigh-bone, the head of the bone being above the level of the pubes.

Fig. 134.



Dislocation of the hip on the pubes. (After Sir A. Cooper.)

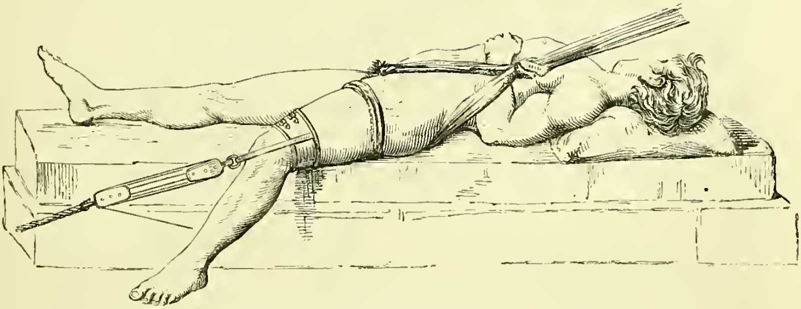
Symptoms.—The limb is everted, abducted, and shortened to the extent of an inch; it cannot be rotated inwards, but can be slightly flexed in a direction outwards. The head of the bone can be felt in the groin, generally to the outer side of the femoral artery, and sometimes it forms a very distinct projection; the great trochanter lies nearer to the mesial line and to the anterior superior spine of the ilium than natural, and the roundness of the hip is consequently lost. This accident can be readily distinguished from a fracture of the neck of the femur by the greater immobility of the limb, but, above all, by the situation of the head of the bone in the groin.

Causes.—A sudden forcing of the body backwards while the thighs are fully extended, or a sudden and forcible extension of the thighs while the body is fixed, or a sudden and simultaneous extension of both body and thighs. More rarely this dislocation has been caused by sudden abduction of the limb, combined with rotation outwards. The dislocation has been brought about by a person unexpectedly putting his foot into a hollow in the ground, when, to prevent falling forwards, he throws his body backwards, and the head of the femur is thus tilted out of its cavity upon the pubes or ilium.

Treatment.—The patient is to be placed on his uninjured side, counter-extension to be made upwards and forwards in front of his body, and extension downwards and backwards behind the axis of the body. After this has been continued for some time a towel is to be placed under the upper part of the thigh, so as to lift the head of the bone over the edge of the acetabulum.

Unusual varieties of dislocation.—Upwards.—There are two forms of displacement upwards—in one, the head of the bone occupies the notch between the anterior superior and the anterior inferior spine of the ilium; in the other, it is situated between the margin of the acetabulum and the anterior inferior spine, or a little to the inner or outer side of this process. The symptoms are, a shortening of the limb from two to three inches, abduction and strong rotation outwards, flattening of the hip, and fulness, or a distinct tumour in the situation of the head of the bone, which moves in unison with the limb. Reduction may be accomplished by extension and counter-extension, combined with adduction and rotation inwards of the limb.*

FIG. 135.



Reduction of dislocation of the hip on the pubes. (After Sir A. Cooper.)

Downwards.—One of the most unequivocal examples of this accident, occurred in the practice of Mr. Luke, at the London Hospital.

The limb was lengthened one inch, without either inversion or eversion. The head of the bone was distinctly felt, and thought to be in the lesser ischiatic notch. The reduction was effected by manipulation. The man dying shortly after, from the effects of broken ribs, the dislocation was easily reproduced, when the head of the bone was found immediately below the acetabulum, and midway between the ischiatic notch and the thyroid foramen. The capsular ligament was lacerated below, and the gemellus inferior and the quadratus femoris were torn through.†

Backwards and downwards.—In this dislocation, the situation of the head of the bone varies slightly, both as to the backward and downward extent of its displacement. Most frequently it is lodged in the depression which exists between the tuberosity and the spine of the ischium.

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* See Malgaigne, tome ii. p. 869 et seq. *Guy's Hospital Reports,* vol i. pp. 79 and 97.

† *Medical Times and Gazette,* June 2, 1858.

In eight out of ten cases Malgaigne* found the head of the bone on a level with the spine of the ischium, while in the remaining two, it was a little below, and it may be dislocated still further backwards and downwards, into the lesser ischiatic notch. In Mr. Adams's case, exhibited at the meeting of the Pathological Society (October 19, 1869), the head of the bone rested on the body of the ischium between its spine and the acetabulum. In this case, the capsule was lacerated, at its posterior part, and the obturator externus, and the quadratus femoris muscles were torn through.† The symptoms of this dislocation closely resemble those of the dislocation into the ischiatic notch: the limb is flexed, adducted, and rotated inwards and slightly elongated, and the head of the bone projects backwards, though, in some cases, it could with difficulty be felt. Reduction is to be effected by extension made in the direction of the axis of the deformed limb, combined with rotation of the thigh outwards, and pressure on the head of the displaced bone.

Forwards into the perinæum.—This dislocation is produced by a heavy weight falling on the back, while the body is bent forwards, and the legs are apart. The symptoms are well marked: the leg and thigh are at a right angle with the body, the toes slightly turned inwards or outwards, the natural form of the nates is lost, and the head of the femur forms a tumour, in the perinæum, which moves with the limb. Reduction is effected by extension in the axis of the displaced limb, aided by manipulation.

Mechanism of dislocation of the hip.—It was long ago remarked by Sir A. Cooper, that there was something a little anomalous in the frequency of the dislocation of the femur upwards and backwards, that being the direction of all others most protected against dislocation, by the 'capsular ligament being there the strongest, the edge of the acetabulum most elevated, and the ligamentum teres offering the greatest hindrance to displacement in that direction;' whereas for the dislocation into the foramen ovale, which is one of the least frequent, all the above conditions are reversed. So again, the greater prevalence of dislocation in the four usual directions, 'is not to be considered as a mere matter of chance, but as the natural result of the influence of the muscles which draw the bone into these positions.' He attributed therefore the occasional occurrence of the so-called anomalous dislocations, either to some mechanical obstacle, as a portion of broken bone resisting the action of the muscles, or to the latter having lost all power of contraction, as in collapse. Under these circumstances, he adds, 'the head will remain where it was placed by the mere physical force which drove it from its socket.'

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* Malgaigne, op. cit.

† *Lancet,* November 6, 1869, p. 640.

It is obvious from the above quotations, that Sir Astley regarded the muscles as the sole agents in drawing the head of the bone into the situations where it is usually found, but he nowhere associates their action with the position of the limb which caused the dislocation; and without taking this into consideration, it would be impossible to account for the dislocation being so much more frequent on the dorsum of the ilium than in any other situation.

If we analyse the causes and symptoms of the four usual varieties of dislocation of the hip, it will be seen that they group themselves thus. In two, the head of the bone is thrown behind the acetabulum; in the other two, it is in front; and if we examine further, we shall see that the two backward dislocations are produced by forced flexion and adduction, combined probably with rotation inwards of the limb; the two forward dislocations, with forced extension and abduction combined with rotation outwards of the limb; in the former, the capsule is lacerated at its posterior and inferior part; in the latter, at the inferior and internal; and it depends probably on the force which produced the injury whether the capsule shall be entirely separated from the femur, or only partially separated, or not separated at all; but merely lacerated to a greater or less extent. This is the principal cause which, I believe, regulates the distance to which the head of the bone shall be drawn or driven, both in the backward and forward dislocations; and it will account partly for the greater difficulty of reducing a dislocation into the sciatic notch, than one on the dorsum of the ilium: in the latter the laceration of the capsule being usually more extensive than in the former, in which there may be a mere slit.

The great frequency of the posterior dislocations as compared with the anterior, is doubtless owing to the greater prevalence of flexed positions of the body and limbs than the opposite: so that when one is overtaken by an accident the body is found more frequently in this posture than in any other. Then, as to the greater frequency of dislocations on the dorsum ilii than into the sciatic notch, it may be accounted for in the same way as a limb becomes shortened when it is fractured, *i.e.* the muscles passing from the pelvis to the thigh missing the resistance they are ordinarily accustomed to—the integrity of the bone in the one case, and the bottom of the acetabulum in the other—contract to their utmost, and a backward dislocation should be always on the dorsum, if the force of the muscles were not counteracted by some other force, which in these cases is nearly always the untorn portion of the capsule. I cannot think with some modern writers that the position of the limb is determined solely by the capsule, and that the muscles exercise no influence; on the contrary, I believe with Sir A. Cooper, that they are the principal, though not the sole agents; and, as in fractures the displacements are occasioned partly by muscular action, and partly by the force which produced the fracture, so in these dislocations, the position of the head of the bone is determined by the joint influences of the force which caused the dislocation, the contraction of the muscles, the rebound of the limb from the abnormal position into which it had been thrown, and the extent of laceration of the capsule.

Let us now direct attention to the two forward dislocations. The position of the limb which gives rise to these displacements we have seen to be, one of forced extension, abduction, and rotation outwards: the capsule is strained at its weakest part, and gives way inferiorly and internally. The abductor muscles which are put on the stretch by the position of the thigh which produces the backward dislocations, are here relaxed, and the adductors stretched; and it depends probably on the degree of extension into which the limb has been forced by the accident whether the head of the bone shall be lodged in the obturator foramen or on the pubes. In simple abduction with slight extension, which produces the obturator dislocation, the anterior part of the two small glutei, with the tensor vaginæ femoris, will be relaxed, and the pectineus and adductors will be put on the stretch, and draw the bone directly into the thyroid foramen; but should there be hyper-extension of the thigh in addition to abduction, the three first-named muscles will be stretched, and combining with the adductors the head of the bone will be drawn upwards on to the pubes or ilium.

It has been recently asserted that 'there is but one primary dislocation of the femur at the hip-joint, namely, that in the foramen ovale, or downwards and inwards;' according to which doctrine about nine-tenths of all the dislocations of the hip are secondary—a statement sufficiently refuted not only by the way in which these dislocations are brought about, but by the specimens referred to by the writer to establish his case.* On the contrary, secondary dislocations are rare, and unless produced by the surgeon in his attempts at reduction, can only be conjectured to have happened on the evidence of the patient.

The limits of this article will not permit me to go into the philosophy of the so-called anomalous dislocations; but the above observations seemed necessary in order to understand the principles that should guide us in our attempts to reduce these dislocations by manipulation.

Reduction by manipulation.—The method of reducing a dislocated limb by manipulation has been practised from the earliest times, but, having fallen into desuetude, has been revived of late years, and now seems likely to supersede the traction method by pulleys. The object of the movements is, of course, to bring the head of the displaced bone close to the opening in the capsule, and the best means of doing this is to make it retraverse the route by which it escaped. 'The reduction of a dislocation is most easy when the dislocated bone follows the same course, but in the opposite direction, to the one along which it originally passed; and the most favourable position of the limb for reduction, is that in which the displacement occurred.' †

Bearing in mind this principle, and having regard to the manner in which the dislocation occurred, it should follow that the proper manipulations for the reduction of the backward luxations, must be flexion and adduction of the limb; and for the forward, abduction and hyper-extension. The first movement brings the head of the bone close to the acetabulum, the second raises it from its edge, when a slight rotation, outwards in the two backward dislocations, and inwards in the two forward, rolls the bone into the socket. The method of reduction may be formulated as follows :—

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* See *British Medical Journal*, June 11, 1868.

† See *Arch. f. klin. Chir.* vol. iv. p. 1. Prof. W. Busch, *New Sydenham Society's Year-Book*, 1863.

1. *Dislocations backwards*, iliac or ischiatic. Flex the thigh to rather more than a right angle, adduct till the knee reaches somewhat over the opposite side of the body, and then rotate outwards, and bring downwards.

2. *Dislocations forwards*, supra- or infra-pubic. Abduct the thigh, rotate it somewhat outwards, and carry it into hyperextension, then rapidly rotate inwards, and place it straight.

Although most recent dislocations of the femur may be reduced with comparative ease, by one or other of the methods described in this article, cases every now and then occur in which the greatest difficulty is experienced. Excluding from consideration maladroit efforts and muscular resistance, the difficulty seems to arise from some of the following causes. 1. A portion of the torn capsule may get in the way, as was well seen in Adams's case, before cited. 2. The strong untorn portion of the capsule may offer resistance. 3. The rent in the capsule may be so small as not to admit of the return of the bone. 4. A portion of the margin of the acetabulum may be broken, and so allow the capsular ligament to yield before the head of the bone.

In illustration of the two last impediments, the reader is referred to Dr. Fenner's case of dislocation on the dorsum ilii; in which that gentleman divided all the muscles passing from the pelvis to the thigh, and found it still impossible to reduce the dislocation, till the rent in the capsule through which the head of the bone had escaped was enlarged from one-half to three-quarters of an inch.*

Mr. Hamilton also exhibited on November 28, 1868, to the Dublin Pathological Society, the preparation of a dislocation into the sciatic notch, which had taken place three weeks previously, and which it had been found impossible to reduce, after repeated attempts. The causes of failure were the smallness of the rent in the capsule, and a fracture of the lower edge of the acetabulum, so that the capsular ligament yielded before the head of the bone.† The success which sometimes attends later attempts to reduce these dislocations is probably owing to the tearing through or detachment from the femur or the acetabulum of those portions of the capsule which formed the impediment in the previous efforts.

A question which the surgeon will sometimes be called on to decide is, how long after a dislocation of the hip may its reduction be attempted? and on this point authorities differ; much must necessarily depend on the age and constitution of the patient, and something on his own wish in the matter. Fabricius Hildanus mentions the case of a lady of rank, in whom reduction was attempted fifteen weeks after the accident, but without success: it has, however, been accomplished after the lapse of six months,* twelve months,† and even longer, as in the remarkable case of Mr. Cornish, related by Sir A. Cooper. Under ordinary circumstances, a reduction of the hip is hardly to be looked for later than eight weeks after the accident, which was the limit placed by the distinguished surgeon just named, beyond which it should not be attempted. Fergusson has never witnessed a successful effort beyond the period of three weeks; but he would deem it quite correct to make trial of all reasonable means at a much longer date, though he could not be at all sanguine of success after two or three months. Before making these attempts it would be well that the surgeon should bear in mind that fractures of the neck of the femur, suppuration in and around the joint, and other injuries which have led to a fatal result, have followed too prolonged and violent efforts to reduce the bone.

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* Hamilton, op. cit. p. 338.

† *New Sydenham Society's Biennial Retrospect* for 1867–8, p. 235.

Equally important with the determination of the longest period at which reduction of this dislocation may be attempted, is the line of practice to be pursued when the injury is complicated with a fracture of the femur of the same side. Guy de Chauliac laid down the following general rule. When a dislocation is complicated with a fracture, let the dislocation be first reduced, and then the fracture, if that is possible; but if it is not possible, let the fracture be first reduced, and after the callus is firm, the dislocation.‡ Boyer considered that a dislocation of an orbicular joint could not be reduced if a fracture were present, and that when the latter had united, the reduction of the dislocation could not be effected, owing to its age. However, Sir A. Cooper relates a case (29th) in which reduction was effected five weeks after the double accident, the fractured bone having become sufficiently firm in this time to admit of extension being made; but this occurred in a youth sixteen or eighteen years of age, and it is doubtful whether the same success would have been attained had the patient been older. The rule would seem to be this: whenever there is room enough above the fracture to fix securely an extending apparatus, reduction of the dislocation should be first attempted, and afterwards the fracture. Several cases are now upon record in which this practice has been successfully carried out: thus, Bloxam reduced a dislocation upon the pubes on the eighth day after the accident;* and M. Etène one into the ischiatic notch, the fracture being in the centre of the bone.† In every attempt of this nature, the limb should be first firmly encased in splints, and preference given to the plan of reduction by manipulation.

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* Gockelius, *Gallicinium Medico-practicum*, Ulm, 1700, p. 228.

† Malgaigne, tome ii. p. 821. Cooper, Case 64.

‡ Malgaigne, tome ii. p. 203.

Dislocations of the Patella

are not of very frequent occurrence, but they may take place in the following directions, viz. outwards, inwards, upwards, and edgeways: they may be complete or only partial, and are more frequently produced by muscular action than any other dislocation, if we except the lower jaw.

Outwards.—This is by far the most common variety of the accident, and may be occasioned either by muscular action or by direct violence; thus, it has been known to take place from a sudden jump on one side to avoid being run over; from wrestling; but more frequently from falling down and striking the inner side of the knee. It is said to occur generally to those who have a slight inclination of the knee inwards; but Malgaigne found only one patient so affected out of forty-six cases of this luxation.

The situation of the patella varies. When only partially dislocated, its inner half rests on the articular surface of the outer condyle, and owing to the obliquity of that surface, its outer margin becomes tilted forwards, forming a ridge in front of the condyle. In complete dislocations, the articular surface of the patella rests on the outer side of the condyle, with its inner margin directed forwards; the breadth of the knee is increased, the limb is slightly flexed and fixed, and any attempt to move it from this position causes great pain.

The dislocation *inwards* is very rare, and seldom complete, and happens usually from falls on a projecting body, by which the patella is struck on its outer edge, and so driven inwards. The symptoms resemble those of the dislocation outwards, but the projection of the patella is of course in front of the inner instead of the outer condyle.

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* *Gazette médicale,* 1833, p. 660.

† Ibid. 1838, p. 751.

From experiments made by Professor Streubel* on the dead subject, it would appear that even incomplete dislocations of the patella outwards cannot take place without laceration of the capsule of the joint; and in complete dislocations, this laceration is often very considerable. The difficulty which is sometimes experienced in reducing this dislocation, after the extensor muscles have been relaxed to the utmost, is owing to the tension of the ligaments being too great to allow of the ridge on the inner surface of the patella being raised above the process on the outer condyle. The professor was not able to produce a dislocation inwards, and he believes that it can only occur in those whose ligaments have been previously relaxed.

Treatment.—This consists in placing the patient in a sitting posture, raising the limb towards the trunk, and then pressing down that edge of the patella which is most remote from the joint; this raises the opposite edge, and it is immediately drawn by the action of the muscles into its natural situation. In a patient who was lately under my care with this dislocation, the knee was reduced with great ease by straightening the leg, and making slight lateral pressure.

In the dislocation *edgeways* the patella is turned on its axis, so as to bring its lateral margins forwards and backwards, and its surfaces sideways; indeed, in some instances this has taken place to such an extent as almost to reverse the normal position of the two surfaces. According to Malgaigne, it is the outer edge of the bone which is most frequently directed backwards, being buried in the fossa between the condyles. There is no difficulty in detecting the nature of these dislocations; the patella can be easily felt in its unnatural position, causing a projection in front of the joint, and a depression on each side, while the joint is immovably fixed in an extended position. This, like the other forms of dislocation of the patella, has been known to occur from muscular action, as in jumping; but most frequently it has resulted from a sudden blow applied to the patella while the knee was bent, as in Mr. Mayo's case, related by Sir A. Cooper, of the life-guardsman, in whom the injury was caused by the knee of another soldier, as the opposite lines rode through each other.

In a case related to me by Mr. Flower, the patient, a young man aged twenty-two, was stepping over the seats of the gallery of a theatre, and fell between them, without, so far as he was aware, striking the knee; severe pain and inability to flex the joint were the immediate results. On examination Mr. Flower found the patella twisted on its longitudinal axis, with its outer edge projecting forwards under the skin, and its inner edge wedged in between the condyles of the femur and the head of the tibia. The limb was extended, and all attempts at reduction by bending the knee, manipulating the patella, &c., produced great pain, and were unavailing till chloroform was given, when, on bending the knee, the bone directly slipped back into its place.

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* Schmidt's *Jahrb.*, 1866, vol. cxxxix. p. 311.

Treatment.—In the cases just alluded to, reduction was effected by suddenly bending the knee. In other cases the same result has been obtained by pressing the edges of the bone in opposite directions while the leg was extended; and in others, both these means, and even the more violent ones of dividing the quadriceps muscle and the ligamentum patellæ, opening the joint, and endeavouring to raise the bone from its position by an elevator, have all failed. The extreme difficulty that has been experienced in the reduction of some of these dislocations is supposed to arise from the upper extremity of the bone having become firmly wedged in the intercondyloid notch.

The dislocation of the patella *upwards* is an exceedingly rare accident, and cannot take place without a rupture of the ligamentum patellæ; this is most usually brought about by a sudden and violent contraction of the quadriceps muscle, made in an effort to prevent falling backwards; the dislocation has also taken place from division of the ligament by sword-cuts, and by falling with the knee on broken glass. The nature of the accident is at once obvious, from the position of the patella, the hollow beneath it, and the inability of the patient to bear the weight of his body on the limb. It is usually followed by a good deal of inflammation of the joint, which should be first subdued, and the dislocation then be treated in all respects as a fracture of the patella.

Dislocations of the Knee-joint.

The tibia may be displaced laterally, or forwards and backwards; each of these dislocations may vary in degree; but the former are always partial, and the latter generally complete; they are usually combined with a slight rotation of the tibia on its axis.

Lateral dislocations.—In these the head of the tibia is partially displaced from the condyles of the femur in a lateral direction. In the dislocation outwards the inner articular surface of the head of the tibia is driven on to or towards the external condyle of the femur, causing much deformity, from the leg and thigh being no longer in the same axis. In the dislocation inwards, the outer articular surface of the head of the tibia is displaced towards the internal condyle, producing an analogous deformity.

The *causes* of these dislocations are falls on the feet, sudden twists of the knee-joint, or blows directed laterally against the lower end of the femur. The deformity which accompanies them is so characteristic of their nature, that a mistaken diagnosis is not likely to occur. They are easily reduced by moderate extension, combined with rotation, or by pressing the displaced tibia into its natural position. There is, however, one accident which very closely resembles them: a separation of the lower epiphysis of the femur, or a fracture partly through it. A little boy, four years of age, was riding behind a cab, when his left leg got between the spokes of the wheel, and he was brought into the Westminster Hospital with an apparent dislocation of the tibia inwards. With very slight extension of the limb, the deformity was removed and distinct crepitus elicited; the existence of this sign, then, is conclusive as to the nature of the injury.

Dislocations in the antero-posterior direction cannot take place without the application of great force. The dislocation of the tibia forwards is most frequently brought about by a forced extension of the knee-joint, or by a heavy body striking the lower and front part of the thigh while the limb is extended. The dislocation backwards is usually the result of direct violence applied to the upper and front part of the tibia when the knee is bent. In both of these displacements considerable injury is done to the soft structures of the joint, and the muscles in the neighbourhood are sometimes torn through. In the dislocation forwards the popliteal artery is also more or less compressed, and this has led to subsequent gangrene of the limb. The symptoms of the dislocation forwards are a swelling in the ham, produced by the condyles of the femur, and another on the front and lower part of the thigh, caused by the head of the tibia, while a depression exists below the former bone and above the latter. The limb is shortened to a variable extent, according as the tibia is higher or lower in front of the femur. In the majority of cases the limb is extended, but in some it has been flexed; the mobility also varies from almost complete fixity to a considerable amount of motion in every direction. In the dislocation backwards, the head of the tibia forms a projection in the ham, and a deep depression exists in front of the knee, below the projecting condyles of the femur. Thus there are the same projections and depressions as in the last-described accident; but their position is reversed. The limb is extended and shortened, and the patella is placed horizontally, with its anterior surface looking downwards and its upper margin forwards. This dislocation is more rare than the preceding one.

Treatment.—The reduction of these dislocations is not difficult; extension must be made from the ankle, in the axis of the displaced tibia, and counter-extension from the thigh, aided, if necessary, by pressing the condyles of the femur upwards, and the head of the tibia downwards. After reduction is accomplished, the joint must be kept perfectly motionless for two or three weeks, and the ordinary remedies employed for preventing or subduing inflammation.

Sub-luxations of the semilunar cartilages.—Inflammation of the knee-joint is liable to be followed by enlargement of the semilunar cartilages, and by elongation of the ligaments which connect them with the tibia. Under these circumstances, a trivial accident, such as striking the toe against some projecting object while the foot is slightly everted, as in walking; or even turning suddenly in bed, should the clothes happen to catch the point of the foot, may cause a displacement of the cartilages, and bring the condyles of the femur into direct contact with the head of the tibia. The symptoms which this gives rise to are a sudden and severe pain in the joint, with inability to straighten it, followed in a short time by the effusion of fluid, and the usual symptoms of synovitis.

Bassius recorded a case of this description in 1731. It happened in a female, who had previously been the subject of severe inflammation of the joint, which ended in enlargement of the external semilunar cartilage. One day, on attempting to put the limb to the ground, she fell down; and Bassius, who was called in, found the cartilage greatly enlarged, and projecting outwards; it was reduced by pressure, but required a plaster and bandage to retain it in its place.* Somewhat similar cases, attended with a marked projection of the internal semilunar cartilage, have been recorded by Malgaigne and by Dequevauviller;[*] Hey[†] and Sir A. Cooper,[‡] on the contrary, observed no projection or other deformity; so that the symptoms may have been due to the existence of loose cartilages in the joint. M. Gimelle[§] has related a case in which this mistake was made; but the true cause having been at length discovered, Larrey cut into the joint and removed the foreign body.

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* Malgaigne, tome ii. p. 968.

Reduction is generally easily accomplished by flexing the knee to its utmost extent, and then suddenly straightening it, imparting to the leg at the same time a slight rotatory movement. Should these manipulations succeed, the patient will be able to extend his limb and move it freely; but the plan is not invariably successful, and it then becomes necessary—all other means of reduction failing—for the patient to wear constantly a bandage or knee-cap firmly around the joint. Even when reduction is effected, similar support of the joint is required, in order to prevent a return of the accident, to which persons who have once suffered are particularly prone. In all cases some degree of inflammation of the joint is set up, which requires the usual treatment for synovitis.

Compound dislocations.—These injuries are among the most serious to which the limbs are liable; for, to the danger incidental to every wound of a large and healthy joint, there is superadded that arising from the forcible separation and displacement of the bones which compose it, and the extensive laceration of the soft structures of and around the joint, including sometimes the popliteal artery. For these reasons it is seldom possible to save the limb, and rarely advisable to make the attempt; nevertheless, if the subject of the accident be young and of good constitution, if the wound in the integuments be small, and the soft parts around the joint not much bruised or the popliteal artery injured, an attempt may reasonably be made to preserve the limb.

Dislocations of the head of the fibula have been occasionally met with, both from relaxation of the ligaments which connect it with the tibia, and from rupture of the same by violence.[||] Reduction is effected by flexing the leg, so as to relax the biceps, and then pushing the head of the bone into its place; after reduction, a compress or cushion must be firmly fixed behind the head of the bone, so as to retain it in position, and it should be kept on for six weeks or two months.

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[*] *Rev. Méd.-chir.* tome vi. p. 180; tome vii. p. 311.

[†] Hey, *Observations in Surgery,* pp. 327 et seq.

[‡] Cooper, op. cit. p. 212.

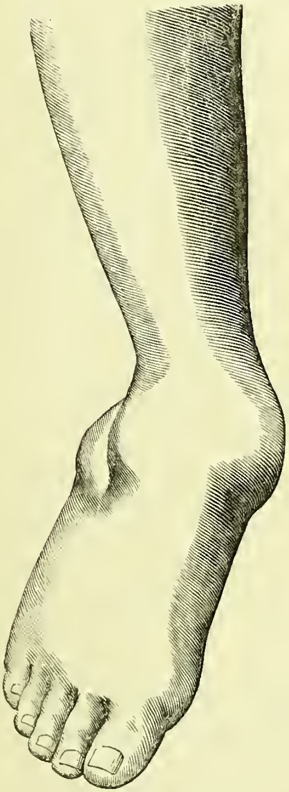
[§] *Gazette médicale,* 1835, p. 221.

[||] See p. 920, for a remarkable case of this dislocation.

Dislocations of the Ankle-joint.

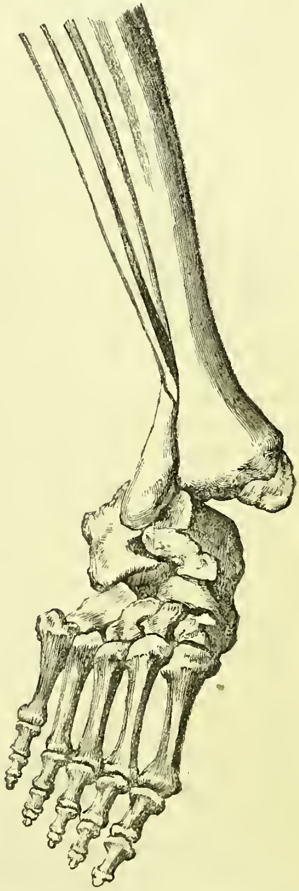
In these dislocations there is a separation of the articular surfaces of the lower end of the tibia and of the upper surface of the astragalus, and much ingenuity has been expended in discussing whether it is the tibia which is dislocated from the astragalus, or the astragalus from the tibia. If the foot were fixed in a vice, and force applied to the leg, the tibia might be separated from its connections with the astragalus, and the injury be called with perfect truth a dislocation of the tibia. If the leg were fixed in the same way, and force applied to the foot, the astragalus might be separated from its connections with the tibia, and the injury with equal truth be called a dislocation of the astragalus or foot; but if instead of fixing either leg or foot, force were applied equally and simultaneously to both, as happens perhaps in the majority of these luxations, the separation of their articular surfaces would be mutual, and neither of the above terms would be strictly correct. It is absurd, therefore, to dispute about which is the bone dislocated; neither would it be possible to adopt the *mode* of displacement as a basis of nomenclature. In all other dislocations, the distal part of the limb is assumed to be displaced, and the proximal end to be in its place; but in the case of the ankle-joint this rule has been arbitrarily set aside, without any equivalent advantage. On the contrary, it has given rise to much confusion of terms, the same accident being differently designated according to the views of the surgeon describing it. Sir A. Cooper, and most English surgeons, speak of the tibia as the bone displaced; while Petit, Boyer, and the majority of French surgeons, refer the displacement to the astragalus: hence the dislocation inwards of the English would be the dislocation outwards of the French. Not less confusion prevails in the designation of the luxations of the calcaneo-astragaloid joint; one writer calling them dislocations of the astragalus, another dislocations of the foot, and a third using these terms synonymously; whilst the majority make no distinction between those cases in which the astragalus maintains its connection with the bones of the leg and is dislocated only from those of the tarsus, and those in which it is separated from both. In the description of these several accidents, therefore, the following terms will be employed. The separation between the astragalus and the tibia will be called a dislocation of the foot at the ankle-joint; the separation between the astragalus and the os calcis and scaphoid will be spoken of as a dislocation of the foot at the calcaneo-astragaloid joint; while the term dislocation of the astragalus will be confined to the separation of this bone both from its tibial and tarsal connections.

Fig. 136.



The foot in Pott's fracture.

Fig. 137.



The bones in Pott's fracture.

(After Pott.)

Dislocations of the foot at the ankle-joint may take place in the following directions, placed according to their frequency—outwards, inwards, backwards, and forwards. In the dislocation *outwards* the fibula is broken from two to three inches above the malleolus; the foot is everted, and its outer edge raised, whilst its inner rests on the ground; a hollow exists at the seat of the fracture, and the extremity of the tibia projects on the inner side of the joint, immediately beneath the skin. This is the accident which goes by the name of Pott's fracture.

> 'The support of the body, and the due and proper use and execution of the office of the joint of the ankle,' observes Pott, 'depend almost entirely on the perpendicular bearing of the tibia upon the astragalus, and on its firm connection with the fibula. If either of these be perverted or prevented, so that the former bone is forced from its just and perpendicular position on the astragalus, or if it be separated by violence from its connection with the latter, the joint of the ankle will suffer a partial dislocation internally; which partial dislocation cannot happen without not only a considerable extension, or perhaps laceration of the bursal ligament of the joint, which is lax and weak, but a laceration of those strong tendinous ligaments which connect the lower end of the tibia with the astragalus and os calcis, and which constitute in great measure the ligamentous strength of the joint of the ankle. This is the case, when, by leaping or jumping, the fibula breaks in the weak part already mentioned, that is within two or three inches of its lower extremity. When this happens, the inferior fractured end of the fibula falls inward toward the tibia, that extremity of the bone which forms the outer ankle is turned somewhat outward and upward, and the tibia having lost its proper support, and not being of itself capable of steadily preserving its true perpendicular bearing, is forced off from the astragalus inwards, by which means the weak bursal, or common ligament of the joint, is violently stretched, if not torn, and the strong ones, which fasten the tibia to the astragalus and os calcis, are always lacerated; thus producing at the same time a perfect fracture and a partial dislocation.' *

Besides the fracture of the fibula, which nearly always accompanies this dislocation, the internal lateral ligament is sometimes torn through, and there may be detached with it more or less of the internal malleolus; or the lower end of the tibia may be broken very obliquely, one portion of it remaining attached to the fibula, where it is connected with that bone by ligament. There is a remarkable if not a unique case, related by Boyer, in which this dislocation was unaccompanied by a fracture of the fibula; but in lieu of this, the entire bone was forced upwards, and its head dislocated from the articular facet of the tibia.†

Simple dislocation of the foot *inwards* is a rare and rather severe accident; greater force being required to produce it than the dislocation outwards; hence, in addition to the tibia being generally obliquely fractured through the malleolus, and separated from the shaft, there may also be a fracture of the astragalus, and of the outer malleolus. If there be no fracture of the latter, the external lateral ligament will be torn through;

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* *Pott's Works*, by James Earle, 1790, vol. i. p. 409.

† Boyer, *Maladies chirurg.* tome iii. p. 883.

but the deltoid remains unaffected by the displacement. The symptoms of this injury are, inversion of the foot, a great prominence of the outer ankle, which almost touches the ground, and a depression on the opposite side of the ankle.

Both of these lateral dislocations are occasioned by a sudden twist of the foot outwards or inwards, as in jumping or falling from a height on the foot; and their reduction may be accomplished by extension made from the foot, the leg and thigh being previously flexed, so as to reduce to a minimum the resistance of the muscles. Two side-splints, with foot-pieces made of wood, leather, or gutta-percha, or the starch-bandage strengthened with millboard, must be applied and kept on for six weeks, the patient being allowed to go about upon crutches.

Dislocation of the foot *backwards* may arise from jumping off a carriage in motion, or from a fall backwards whilst the foot is confined; from either cause, the capsular and part of the deltoid ligaments may be ruptured, the fibula broken above the malleolus, and the tibia forced from the astragalus on to the navicular and cuneiform bones. The symptoms of this accident are, a shortening of the foot and a lengthening of the heel, with a depression above the latter. The toes are pointed downwards, and the extremity of the tibia forms a projection in front of the ankle. Reduction may be accomplished in the same manner as in the last-described dislocation, and a similar apparatus is sufficient for the after-treatment.

Dislocation of the foot *forwards* is so rare that Sir A. Cooper never saw a case, and but few such are on record. One of the best-described cases is that recorded by Mr. R. W. Smith, of Dublin.*

The subject of the accident was a sailor, who, while assisting to raise a very heavy cask on board ship, having at the same time one leg much flexed on the foot, and the thigh on the leg, was struck by the falling of the cask just above the knee, forcing the distal end of the tibia backwards from off the astragalus on to the upper and posterior surface of the calcaneum. The symptoms of this accident were, a lengthening of the dorsum of the foot to the extent of one inch, and a shortening of the leg to the extent of half an inch, the two malleoli being that much nearer the ground. The projection of the heel had disappeared, and the tibia formed a remarkable projection in front and to the inner side of the tendo-achillis. The fibula was uninjured; but the extremity of the inner malleolus had been fractured.

The only accident with which this could be confounded is a fracture of the tibia immediately above the ankle-joint; but the situation of the malleoli would be decisive as to the nature of the injury. In the few cases of this accident which have been published, reduction was not effected, and the patients remained very lame; but there seems to be no reason why cases of this description, if seen early and properly recognised, should not be reduced in a similar manner to the lateral dislocations, and treated in all respects similarly.

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* *Dublin Quarterly Journal of Medical Science*, May 1852.

Compound dislocations of the foot at the ankle-joint take place in the same directions as the simple dislocations, and are accompanied by similar injury to the ligaments and bones of the joint. There is, however, superadded the wound in the integuments communicating with the joint, and there may be also laceration of the blood-vessels and tendons, and extensive comminution of all the bones of the joint, and even of the os calcis.

It would be impossible to lay down rules for the treatment of every case; each must be studied separately, and the means adapted to the circumstances present. If arteries are wounded and bleeding, they must be tied; if bones are comminuted the pieces must be removed; resection may be required in some cases, and amputation in others. As a general rule, amputation is improper, and, except under the circumstances to be presently mentioned, the preservation of the limb ought always to be attempted. Our first object, therefore, should be to reduce the dislocation, by bending the leg on the thigh, and making extension and counter-extension from the foot and thigh. Reduction having been effected, and the wound cleansed from dirt and other foreign bodies, the limb must be placed on a hollow splint with a foot-piece, in such a position as admits of the easy application of dressings to the wound without disturbing the joint; then a piece of lint may be laid on the wound, and kept wet by the dropping of cold water from a bottle or other apparatus suspended above it. Should the case proceed favourably, little or no other treatment will be necessary, unless it be the occasional administration of opiates to allay irritation and relieve pain. Some months, however, must elapse before the patient will be able to bear upon the limb; and however complete the recovery, the movements of the joint are not always restored. It was mentioned just now that, as a general rule, amputation should not be had recourse to in these accidents; nevertheless, there are circumstances which justify, and even demand, this operation. Thus, primary amputation may be advisable on account of the advanced age of the patient, or the extensive laceration and contusion of the soft parts, especially if complicated with wounds of the blood-vessels or with extensive shattering of the bones. Amputation may likewise be necessary some time after the accident, when the attempt to save the limb has failed, through diffuse inflammation or sloughing of the soft parts of the foot and leg or consecutive hæmorrhage, or on account of severe constitutional disturbance threatening the life of the patient.

Dislocations of the Foot at the Calcaneo- and Scapho-astragaloid Joints, commonly called Dislocations of the Astragalus.

In the last-described dislocations, the astragalus maintained its normal relations with the other bones of the foot, and altered them only as regards the bones of the leg; in the dislocations we are now about to speak of, the astragalus retains its connections with the latter, but is no longer in normal relation with the former. Till a comparatively recent date, no distinction was made between this accident and the one next to be described, in which the astragalus is separated from the bones both of the leg and of the foot; but under the general term dislocation of the astragalus were included both these forms of injury. It is not therefore to be wondered at, that those who first recognised the distinction, and perceived that two different accidents had hitherto been confounded with each other, should not have adopted a uniform nomenclature in reference to the newly-discovered injury. Accordingly, it has been described under the following synonyms: (1) dislocation of the astragalus; (2) partial dislocation of the astragalus; (3) single dislocation of the astragalus; (4) dislocation of the head of the astragalus; (5) luxation sous-astragalienne; (6) luxation métatarsienne; (7) dislocation of the scaphoid and calcis from the astragalus; (8) dislocation of the os calcis and astragalus. In adopting a nomenclature which has not hitherto been employed to designate this injury, the writer has been influenced mainly by a desire that it should at once express the real nature of the accident, and at the same time not violate the rule which regards the distal part of the limb as that which is displaced. Both these conditions are more perfectly fulfilled by the title at the head of this section than by any of those previously employed.

It may be objected, that it is only a part of the foot which is displaced, and therefore to call the accident a dislocation of the foot is not correct; but for this objection to be valid, it must first be shown that the foot deprived of a toe, or the hand of a finger, is thereby disentitled to its distinctive appellation.

The principal varieties of this dislocation are four in number, viz. two lateral, which are the most common; one backwards, which is very uncommon; and another forwards, which is still more rare. The chief lesions which are found in the simple dislocations are rupture, partial or complete, of the interosseous ligament between the os calcis and astragalus, and of the synovial capsules between these bones. The scapho-astragaloid ligament is also torn through, together with the lateral ligaments of the ankle-joint, sometimes on both sides, but more frequently on the one which is opposed to the direction of the displacement. Partial fractures of the astragalus, os calcis, or both bones, or of one or other malleoli, injury or rupture of some of the tendons, blood-vessels, or nerves, are occasionally met with in the compound varieties of this accident.

A question of some interest in connection with these displacements is, whether the scaphoid, with the rest of the foot, can be luxated from the head of the astragalus, the body of this bone retaining its connections with the os calcis through the unruptured interosseous ligament; or, to make use of the phraseology generally employed, whether the head of the astragalus can be luxated without its body undergoing displacement. Till the publication of M. Broca's memoir,* this form of injury was generally believed in; but that acute surgeon, arguing from the anatomical relations of the bones of the tarsus, especially those of the os calcis and cuboid, questions the possibility of its occurrence, and proves incontestably that some of the recorded examples were really luxations of the whole foot at the calcaneo-astragaloid joint, with rupture of the interosseous ligament, while others he considers had their origin in errors of diagnosis. Without doubting the frequency of diagnostic errors, most surgeons will probably be more disposed to admit with Malgaigne as 'très-possibles les subluxations sur le scaphoïde signalées par Boyer et Richerand, et même les luxations complètes de la tête de l'astragale avec un déplacement à peine sensible du corps de l'os sur le calcanéum.'† Indeed, the possibility of such an injury must now be considered as placed beyond a doubt by a case recorded by Pollock, in which, in a well-marked dislocation of the foot inwards, the interosseous ligament was found to be unruptured.*

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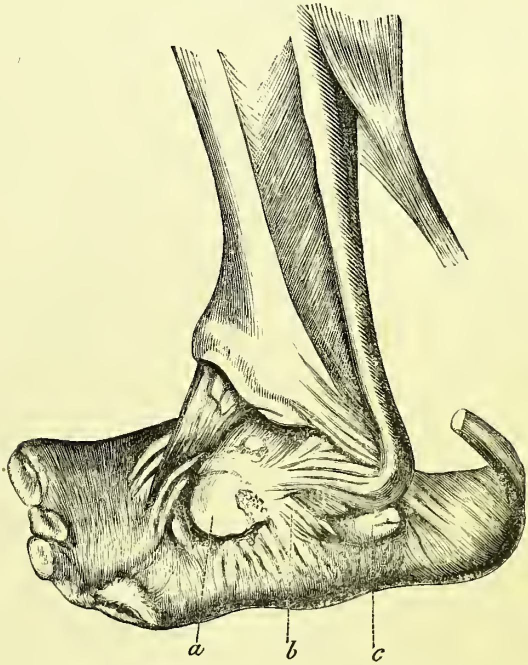
* *Mémoires de la Société de Chirurgie,* tome iii. p. 566.

† Op cit. tome ii. p. 1031.

In the dislocation of the foot backwards (commonly called dislocation of the astragalus forwards), the head of the astragalus rests upon the instep, where it forms a tumour, projecting almost through the skin. The foot is somewhat extended and shortened in front of the leg, but elongated behind. Slight flexion and extension can be made, though attended with pain.

Fig. 138.



Dislocation of the foot at the calcaneo- and scapho-astragaloid joints. The tendo-achillis is seen to have been divided, by which means the dislocation was reduced during life. After death the tarsus was put into the inverted position which it occupied at the time of the accident. *a.* The head of the astragalus displaced from its connection with the scaphoid. *b.* The interosseous calcaneo-astragaloid ligament, not completely ruptured. *c.* The posterior articular surface of the astragalus, marked by a slight fissure. (From the Museum of St. George's Hospital. Pollock's case.)

Perhaps the best example of this variety of dislocation is that published by Macdonnell, of which the following is an abstract. On August 6, 1838,

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* *Med.-Chir. Trans.* vol. xlii. p. 39.

Mr. Carmichael was riding at a brisk trot, when his horse suddenly fell. To prevent being pitched forwards, he threw himself back in the saddle, and strongly extended his legs to meet the ground. The shock of his descent was accordingly received upon the anterior extremities of the metatarsal bones, especially the metatarsal bone of the great toe of the right foot, which alone came to the ground. The following were the symptoms: 'The toes were turned outwards, the inner edge of the foot forming an angle of about 30° with its natural direction; the sole was slightly turned outwards, and the outer edge slightly elevated. The concavity of the tendo-achillis posteriorly was manifestly increased, and the heel lengthened. On grasping the soft parts between the tendo-achillis and tibia, we found the distance between these parts much greater than in the other foot. The absence of the hard projection, which would have been formed by the upper articulating surface of the astragalus, had it passed backwards with the other tarsal bones, was evident. The malleoli were perfectly defined. Below and before the inner there was a hard prominence, over which the skin was tense, formed by the inner surface of the astragalus brought into relief by the dislocation, and the slight eversion of the sole of the foot. Much the most striking part of the deformity consisted in a prominence on the dorsum of the foot. Immediately in front of the tibia it presented a flat surface broad enough to receive the finger, and from which there was an abrupt descent upon the anterior part of the tarsus. Over this projection, caused by the head of the astragalus, the integuments were so tense that it was evident a very small additional force would have driven it through the skin. Lastly, on taking the distance from the point of the internal malleolus to the extremity of the great toe with a tape-measure, I found it to be exactly an inch less than the distance between the same points in the left foot. We could detect no fracture. The foot could be flexed and extended, but it occasioned great pain.' *

Reduction was attempted by making extension from the foot, and counter-extension from the knee, previously bent to the utmost; at the same time the heel was pressed forwards, and the astragalus and tibia backwards, the toes drawn inwards, and the outer edge of the foot depressed. These means failing, pulleys were applied, and the manipulation continued, and in about ten minutes, the pain having become unendurable, Mr. Carmichael made a violent effort, the pulleys were relaxed, and the reduction was effected at the same moment without noise.

Dislocation of the foot forwards is exceedingly rare. Malgaigne could find but one example, which is recorded by M. Parise.†

It happened to a quarryman who, while at work, with his left foot resting on a block of stone, and his right on the ground, was thrown forcibly forwards by the falling of a mass of stone; the thigh being at the time strongly flexed on the trunk, the leg on the thigh, and the foot on the leg. The following were the symptoms: the foot was flexed on the leg; the projection of the heel had disappeared; and the extremities of the bones of the leg, with the astragalus, were directed to the posterior part of the calcaneum. As no crepitus could be elicited, the accident was presumed to be a dislocation; but the swelling and pain were so great, that a complete examination could not be made, and reduction was not attempted. Nine months afterwards the condition of the limb was as follows: the foot was flexed at a right angle with the leg, its point inclined inwards, and its inner border slightly depressed; it was elongated in front of the bones of the leg, and the projection of the heel was completely effaced. At the level of, and a little below the malleoli, posteriorly, was a bony projection, which pushed backwards the tendo-achillis beyond the heel. Above this projection was another less marked, formed by the posterior and inferior margin of the tibia; the malleoli were not separated from each other, nor did they present any traces of fracture. The extensor tendons of the toes were stretched over the instep, and beneath these on the outer side was a projection, which appeared to be the head of the astragalus, and immediately in front of this a depression. Flexion and extension of the ankle-joint existed to a limited extent.

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* *Dublin Journal*, 1839, vol. xiv. p. 235.

† *Annales de la Chirurgie*, 1845, tome xiv.

Dislocation of the foot sideways.—The lateral dislocations of the foot at the calcaneo-astragaloid joint are most frequently compound and incomplete; that is, the astragalus still rests on a portion of the os calcis, and is not placed at its side as in the complete dislocations. These dislocations are most frequently brought about by forced movements of adduction or abduction, and the foot retains very nearly the position in which it was thrown by the accident; but in some cases it has been forced from under the astragalus without any deviation of its borders or surfaces, as happened in a case reported by Mr. Hancock,* in which the foot was thrown outwards; and in another case of Mr. Paget's, in which it was thrown inwards. The symptoms of a luxation outwards are, abduction of the foot, its outer border being raised, and its inner resting on the ground. The outer malleolus is buried in the fossa caused by the eversion of the foot, and the inner malleolus and the head of the astragalus project unnaturally inwards. In the complete dislocation this projection will be greater, and, in addition to these symptoms, there will be a shortening of the limb, and the extremity of the inner malleolus will be placed nearer to the sole of the foot. In thirteen examples of this injury collected by Broca, nine were compound, and in six the fibula was broken.

In the dislocation inwards, the foot is inverted and its inner border raised, resembling the varus form of club-foot. The head of the astragalus and the outer malleolus project beyond the outer border of the foot, and a deep depression exists below. On the inner side of the foot an elongated projection, formed by the inner border of the calcaneum, completely masks the inner malleolus. The scaphoid bone can be felt nearer to the os calcis than natural, and thus the inner border of the foot is shortened and somewhat concave, while the outer is lengthened and unnaturally convex. The tibia and fibula are unbroken.

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* *Lancet,* 1844, vol. ii. pp. 35, 70, and *Med.-Chir. Trans.* vol. xlii. p. 46.

Two cases of this dislocation have been described by M. Letenneur,* and two by M. Malgaigne.†

Diagnosis.—There are several injuries with which dislocations of the foot at the calcaneo-astragaloid joint may be confounded, the principal of which are the following:

1. Dislocations at the ankle-joint.
2. Fractures of the tibia just above the ankle-joint.
3. Fractures of the astragalus in a horizontal or oblique direction.
4. Dislocations of the astragalus properly so called.

1. From the lateral dislocations of the foot at the ankle-joint they may be distinguished by the projection of the head of the astragalus in front of the bones of the leg, and by the persistence of the movements of flexion and extension; while fracture of the malleoli, which is the rule in dislocations at the ankle, is the exception in the corresponding sub-astragaloid dislocations. In the antero-posterior luxations at the ankle, the upper pulley-like surface of the astragalus will project either in front of or behind the leg-bones, and the whole limb will be shortened; while both these signs will be absent in the sub-astragaloid dislocations. 2. Fractures of the tibia just above the ankle-joint, with displacement of the foot backwards, also bear some resemblance to the sub-astragaloid dislocations of the foot in the same direction, but may be distinguished from them by the same signs as distinguished the luxation without fracture just given, and by the existence of crepitus; to which we may add that the dislocation consequent on fracture is rarely or never complete, and the lower sharp ridge of the broken bone can be felt projecting beneath the skin. 3. Fractures of the astragalus, when occurring in a horizontal or oblique direction, are generally accompanied with distortion, resembling somewhat the dislocations we are treating of; the foot with the lower fragment of the astragalus being carried in one direction, and the leg with the upper fragment in the opposite. These

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* *Rev. Méd.-chir.* 1854, tome xii. p. 19.

† Malgaigne, op. cit. tome ii. p. 1044.

accidents, however, are rare, and, in all the recorded examples met with, were compound; so that the nature of the lesion was manifest; but in a simple fracture of this nature, the diagnosis might probably be established by the crepitation, and by the absence of the projection caused by the head of the astragalus. 4. Luxations of the astragalus from all its connections are unquestionably the accidents which have been most frequently confounded with the sub-astragaloid dislocations; but the shortening of the leg, produced by the approximation of the tibia to the os calcis, the relation of the head of the astragalus to the malleoli, and the loss of motion at the ankle-joint, are sufficient to distinguish them.

Treatment.—What cannot fail to have struck any one who has looked over the published cases of this dislocation, and that of the astragalus with which it has been confounded, is the ease with which some of these have been reduced, and the extreme difficulty, and even impossibility, of its reduction in others. These difficulties are owing to the following circumstances. 1. The posterior edge of the astragalus may become wedged in the fossa between the articulating facets of the os calcis. This has happened in several instances, and has hitherto presented an insuperable obstacle to reduction: thus in M. Roux's case of dislocation outwards, in which amputation was performed, Nélaton found the head of the astragalus resting on the inner surface of the scaphoid bone, while the deep fissure between its two inferior articulating surfaces received a portion of the sharp margin which surrounds the articulating cavity on the posterior surface of the scaphoid; the posterior edge of the astragalus was also engaged in the fossa which separates the two superior facets of the calcaneum.* 2. The head of the astragalus may be driven against the tendon of the tibialis posticus muscle, and either rupture it, or escape above or below it. In the last case, the neck of this bone will be firmly constricted between the tendon and the calcaneo-scaphoid ligament; and extension made to reduce this form of dislocation will be the most effectual means of preventing it from taking place. 3. In the dislocation inwards the head of the astragalus will rupture or push before it the extensor tendons on the dorsum of the foot, and no obstacle will be presented by them to the reduction; but the scaphoid and anterior part of the foot are drawn towards the heel, so that the space between the scaphoid and os calcis, occupied normally by the under and inner part of the head of the astragalus, is obliterated by the action of the same muscles as are engaged in the production of talipes varus; chiefly the gastrocnemius and soleus, and the two tibial muscles. The dislocation forwards is so rare that no dissections, I believe, have been made to show what were the obstacles to reduction; but looking at the form of the os calcis, it would seem highly probable that it was due to the outer border of the posterior facet of the calcis being engaged in the inter-articular fossa on the under-surface of the astragalus. With our present knowledge, then, of the chief circumstances which have hitherto so frequently baffled the best attempts to effect reduction of these dislocations, it would seem expedient in all cases of simple luxation which have not yielded to moderate extension and manipulation, to divide subcutaneously one or more of the tendons of those muscles which offer the greatest resistance to our efforts. In all, reduction would probably be facilitated by division of the tendo-achillis, and in the lateral displacements one or both tibials may also require division.* If these means fail, all further operative measures should be abandoned for the moment, and only again had recourse to if the integuments slough, and the exposed astragalus becomes necrosed, when a part or the whole of this bone may be removed with very little risk to the patient. In the dislocations, compound from the beginning, reduction should be attempted, as in the simple forms; but in the event of failure, the astragalus should be removed without delay.

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* *Bull. de la Soc. anat.* 1835, tome x. p. 38.

Dislocations of the Astragalus properly so called.

These are the dislocations to which Boyer has applied the term double, on account of the separation of the astragalus from both the tibia and os calcis. According to Malgaigne, these are more common than the sub-astragaloid dislocations, while Pollock believes them to be the most rare of all dislocations implicating the bone. Unfortunately we do not at present possess sufficiently reliable data on which to determine their relative frequency. The astragalus may be displaced in the same directions as it occupied in the last-described luxations, viz. forwards, backwards, and laterally; to which must be added certain peculiar and rare displacements of the bone, in which it becomes rotated, to a greater or less extent, on one or other of its axes. Thus it has been found rotated from a quarter to half a revolution on its antero-posterior or long axis, so as to bring the upper and lower surfaces of the bone to look sideways, or even completely to reverse their normal position; it has also been found rotated around its vertical axis, the head of the bone looking inwards, and the outer surface of its body forwards. Or, more remarkable still, these two forms of luxation have been combined, as in a case related by Thierry, in which the head of the bone was directed backwards, and the posterior extremity of the bone forwards and outwards. At the same time it was so rotated on its antero-posterior axis that the trochlea looked inwards, and the tibia rested on the inner side of its body, which was upwards, its inner edge fitting exactly into the angle formed by the malleolus with the rest of the mortise.*

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* See Pollock, *Med.-Chir. Trans.* vol. xlii.

Dislocation of the astragalus forwards.—In this form of displacement the astragalus is thrown either directly forwards, or, what is more common, with an inclination of its head to the inner or outer side. The symptoms do not differ as regards the position of the astragalus with reference to the other bones of the foot from those which characterise the dislocations described in the last section, but the relation of the displaced bone to the bones of the leg offers an important point of difference by which they may be distinguished. Thus, the astragalus being thrown forwards from underneath the tibia, forms a projection in front of it; while the latter, now resting on the os calcis, appears sunk into the dorsum of the foot, and the movements of the ankle-joint are of course annihilated. In some of these dislocations forwards, the head of the astragalus has been thrown so much inwards and downwards as to bring the long axis of the bone into a line with that of the tibia, and so to appear as if it were a continuation of that bone. The position of the foot is always found to vary with that of the astragalus, and to be more or less everted or inverted, according as the bone is thrown towards one or the other side.

Dislocation of the astragalus backwards is a somewhat rare accident, but two excellent examples of it have been published by Mr. Benjamin Phillips, in the *Medical Gazette* of 1834, vol. xiv., one of which is here transcribed.

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* Examples of these forms of injury have been recorded by Laumonier (*Journal de Fourcroy*, 1791, tome ii. p. 40); Foucher (*Revue méd.-chir.* 1845, tome xvii. p. 203); Dupuytren (*Annuaire méd.-chir. des Hôpitaux de Paris*, 1819, p. 28); Turner (*Transact. Provin. Med. and Surg. Assoc.* vol. ix. p. 417).

'Mr. G. was driving out in a phaeton, when the horse became unmanageable, and the reins broke. Mr. G. threw himself from the carriage, with the intention of stopping the horse; he alighted upon his feet, but immediately fell forward to the ground. The kind of injury which had occurred was immediately apparent by the remarkable projection which was presented just above the heel. The tendo-achillis was pressed out by the displaced astragalus, so as to form an angle of 40°, and at one point the bone had reached so near to the surface that vesication was produced directly over it. The anterior part of the foot appeared shortened, and a projection was presented anteriorly by the inferior extremity of the tibia. There was very little ecchymosis, and it was not at all evident upon what portion of the foot he had rested on coming to the ground. It appeared probable that the foot was suddenly and forcibly flexed, because in that movement the anterior border of the articular surface of the tibia meets the neck of the astragalus, which arrests the movement of flexion before it has proceeded far enough to produce luxation of the foot upon the leg.' This conjecture of Mr. Phillips is rendered highly probable by the mode in which the luxation was produced in another case, which he describes in the same journal. The gentleman was playing at cricket, and, while running very rapidly after the ball, a gutter which was in his course was not observed. The toes rested on the further side of this gutter, while the heel was jammed directly into it, and he fell forward. The appearance of the limb in these two cases was very similar.

The dislocated astragalus, instead of being thrown directly backwards, is sometimes found on the inner or outer side of the tendo-achillis, between this and one or other of the malleoli. An example of the displacement backwards and inwards, which was reduced, occurred at University College Hospital, in the year 1839, and is reported in the July number of the *Lancet* of that year. A compound dislocation of the astragalus, backwards and outwards, which could not be reduced, and in which the bone was therefore extracted, is recorded by Turner, in his collection of cases.*

Dislocations of the astragalus inwards and outwards.—These displacements cannot be complete without being at the same time compound, when the nature of the injury is thus rendered manifest. Even in the incomplete luxations, if the bone be not reduced, sloughing of the soft parts over the projecting astragalus takes place subsequently, and reveals the nature of the displacement. It is difficult to imagine how either of these luxations can take place without a fracture of the malleoli; yet Boyer assures us, that in a case of dislocation of the astragalus inwards, to which he was called, there was no fracture of any bone, nor any separation of the tibia from the fibula. On reading his description of the case, it would appear to be a dislocation of the foot outwards, at the calcaneo-astragaloid joint, while at the same time the astragalus was rotated on its long axis, so as to place its upper or trochlear surface inwards, and its outer surface upwards. Thus it can scarcely be called a dislocation inwards, inasmuch as the bone did not completely leave the mortise which is formed for it by the tibia and the fibula. Two other very similar cases have been recorded by Aubray* and Robert† in both of which the bone had undergone the same rotation on its axis; but the displacement inwards was greater, the trochlear surface projecting in this direction beyond the inner malleolus.

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* Loc. cit.

Treatment.—The reduction of a complete dislocation of the astragalus, without divisions of some of the tendons which pass from the leg to the foot, would appear at first sight to be well-nigh impossible; and though several such cases have been published, it is highly probable that some of them at least were instances of partial and not of complete luxation. This difficulty of reduction is owing to the obliteration of the space normally occupied by the astragalus, through the action of the powerful muscles which pass from the thigh and leg to the foot. If moderate extension and counter-extension under chloroform, together with manipulation fail, the tendo-achillis should be divided, and this likewise failing, the bone had better be left in its abnormal situation, and no immediate attempts made to remove it. The propriety of leaving the bone, instead of removing it in the first instance, was strongly insisted on by Sir A. Cooper; and the judiciousness of this practice has been fully proved by the more recent researches of M. Broca, who has shown that in 36 cases of irreducible simple luxation of the astragalus, in which immediate extraction of the bone was performed, 9, or one-quarter, were fatal; while in 43 irreducible cases in which no primary operation was performed, there were only 2 deaths. Of the remaining 41 cases, amputation was performed in 2; and extraction of the bone, after it had become exposed by the sloughing of the integuments, in 16; all of which recovered: while no operation of any kind was required in 23, the patients recovering with a useful limb, though of course with some deformity and lameness.* The practice to be pursued in compound luxations of the astragalus differs from that recommended in the compound sub-astragaloid dislocations, for the reason that the bone is more completely separated from its connections, and that the space which it naturally occupies is obliterated by the approximation of the tibia and the calcis. The first would render it more liable to death, and the second would increase the difficulty of returning it. If we add to these two circumstances the fact of there being an open wound communicating with the isolated and detached bone, it seems more than probable that, even if reduction were effected, its vitality would be so far impaired as to render its subsequent extraction necessary, while the irritation it would be likely to set up might jeopardise the limb, or even the life of the patient. Under these circumstances, the most proper and safe course is to remove the bone in the first instance, without making any attempt at reduction.

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* Aubray, *Journ. de Méd.* 1771, tome xxxvi. p. 351.

† Robert, *Gazette des Hôpitaux,* 1846, p. 384.

Dislocation of some of the other Tarsal Bones.

Dislocation of os calcis, &c.—M. Broca, after a careful analysis of the recorded cases of this dislocation, decides that the evidence in favour of them is not conclusive.

Malgaigne agrees with Broca, so far as the cases he has adduced as evidence are concerned, yet cites two instances which came under the charge of M. Jourdan at the Hôtel Dieu of Marseilles, which, he considers, establish beyond doubt the possibility of this accident taking place. In one of these the relations of the astragalus, scaphoid, and leg bones, and the movements of flexion and extension of the foot, were perfect. The os calcis projected considerably beneath and external to the outer malleolus, and its anterior articular process was separated from the cuboid. The luxation was caused by a heavy piece of wood falling on the foot from a height; and M. Jourdan easily reduced it by making pressure on the foot and os calcis in opposite directions.† In 1847 Mr. Canton published in the *Lancet* of May 15 'An account of the dissection of an unusual form of displacement of the astragalus,' but which Malgaigne considers an example of dislocation of the calcaneum outwards.

Dislocations of some of the other tarsal bones are occasionally met with; thus Burnett has described, in the *Medical Gazette* for 1837, vol. xix. p. 221, the case of a gentleman who, in taking a leap while fox-hunting, dislocated the scaphoid bone from its connections with the cuneiform bones. Burnett found a wound three inches in length over the instep, through which the scaphoid and astragalus protruded, the three facets of the former bone being directed forwards and outwards. By making steady pressure on this bone for fifteen minutes it was reduced, the wound healed, and the patient recovered the free use of the foot. Cases have been recorded by Piedagnel, Walker, and others, in which the bone has been separated from the astragalus as well as from the cuneiform bones.*

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* *Gazette des Hôpitaux*, 1852, p. 371.

† Malgaigne, tome ii. p. 1069.

Dislocations of the cuneiform bones.—Two forms of luxation of the internal cuneiform bone have been met with; in one it is separated from the scaphoid in company with the first metatarsal bone; in the other it is separated from all its articulations, and is thrown upwards and inwards. The three bones are also sometimes luxated together upwards, and are reduced by pressure without much difficulty.

Dislocations of the first row of tarsal bones from the second row, or of the os calcis and astragalus from the cuboid and scaphoid bones.—The reality of this accident is somewhat problematical, and has not yet been verified by dissection. Its assumed existence rests chiefly on the evidence of Petit and Sir A. Cooper; the first of whom affirms that he had met with two cases, but gives no description of the symptoms, and merely contents himself with the following brief remark: 'Cette maladie se connaît par la seule difformité, elle indique le côté où les os se trouvent logés.'† Sir A. Cooper does not profess to have seen the case he describes, which is given on the authority of the students of Guy's Hospital, who had reduced the displacement before he saw it. 'The calcis and astragalus remained,' we are told, 'in their natural situations, but the forepart of the foot was turned inwards upon these bones. The appearance was so precisely like that of a club-foot, that they could not at first believe that it was not a natural defect of the kind.'‡ Another example of this injury has been recorded by Liston.§ A boy, aged fourteen, fell from a height of forty feet, and alighted on the extremity of the right foot. The scaphoid and cuboid bones, it is stated, were dislocated upwards, and the foot was half an inch shorter than the other. Reduction was not attempted, but the patient left the hospital in three weeks able to stand on the foot.

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* *Journal univ. et hebdom.* 1831, tome ii. p. 208; *The Medical Examiner*, 1851, p. 203.

† Petit, *Maladies des Os*, 1723, tome i. p. 321.

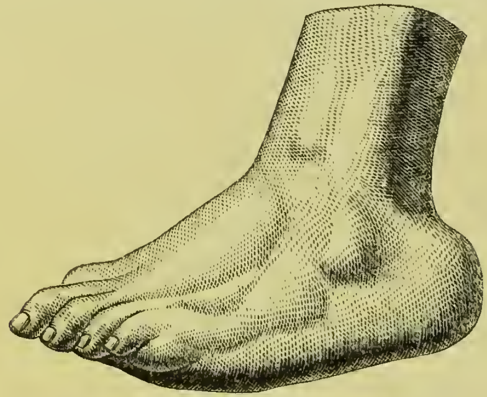
‡ Cooper, op. cit. p. 336.

§ Liston, *Practical Surgery*, p. 140.

Dislocations of the Metatarsal Bones.

One or more of these bones are sometimes displaced, or the entire range may be thrown upwards, downwards, outwards, or inwards, the first direction being the most frequent. Some rare examples have been seen in which contiguous bones have been thrown in opposite directions; the three first, for example, being thrown downwards, and the fourth upwards. Although these dislocations can only be occasioned by great violence, they are rarely compound; they are most frequently caused by falls on the toes, or force directed on the anterior part of the foot from above downwards, or laterally. The luxations upwards and downwards are readily diagnosed by the shortening of the foot, without a corresponding elongation of the heel, and by the projection and depression on the instep. Dr. Smith of Dublin, who has given one of the best accounts of the upward dislocation of these bones,* calls attention to the peculiar alteration in the form of the sole of the foot, which, instead of presenting its natural concavity, becomes convex both in its antero-posterior and transverse diameters. The lateral displacements are readily distinguished by the projection at the inner or the outer border of the foot. In an analysis of twenty-nine cases of these tarso-metatarsal dislocations, Dr. Hitzig found thirteen were of single bones, and sixteen of the entire metatarsus. It would seem also, that unreduced dislocations of the entire tarsus in a vertical

FIG. 139.



Dislocation of the metatarsus. (After R. W. Smith.)

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* Smith, op. cit. p. 226.

direction, give rise to less inconvenience than the lateral displacements. Recent dislocations are best reduced by manual extension and counter-extension, with pressure of the thumbs on the displaced bone under chloroform.*

Dislocations of the phalanges are rare. Of twenty-two cases in which the first row were dislocated, Malgaigne states that nineteen were of the great toe, and three of all the toes at once. The displacements are always upwards, and may be complete or partial, and are generally compound. There is a certain analogy between the luxation of the first phalanx of the great toe and that of the corresponding phalanx of the thumb, and a similar difficulty is experienced in its reduction; this, it has been conjectured, is owing to the resistance of the internal lateral ligaments and the tendons of the short and long flexor muscles. Reduction has sometimes been effected by traction only, but at other times all means, even dividing the internal lateral ligaments and the flexor tendons, have failed. Dislocations of the second row of phalanges are so rare that Malgaigne could find but two examples of the accident on record; one was a compound dislocation affecting the great toe, and the other the third toe; both were returned. These accidents, he states, are almost peculiar to jockeys, and arise from falls from horseback with the foot underneath the animal. They have also been occasioned by the passage of carriage-wheels over the foot.

CARSTEN HOLTHOUSE.

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* *New Syd. Soc. Biennial Retrospect,* 1865-6, p. 273, from *Berliner Klin. Wochenschrift,* vol. ii. p. 39-42, 1865.

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